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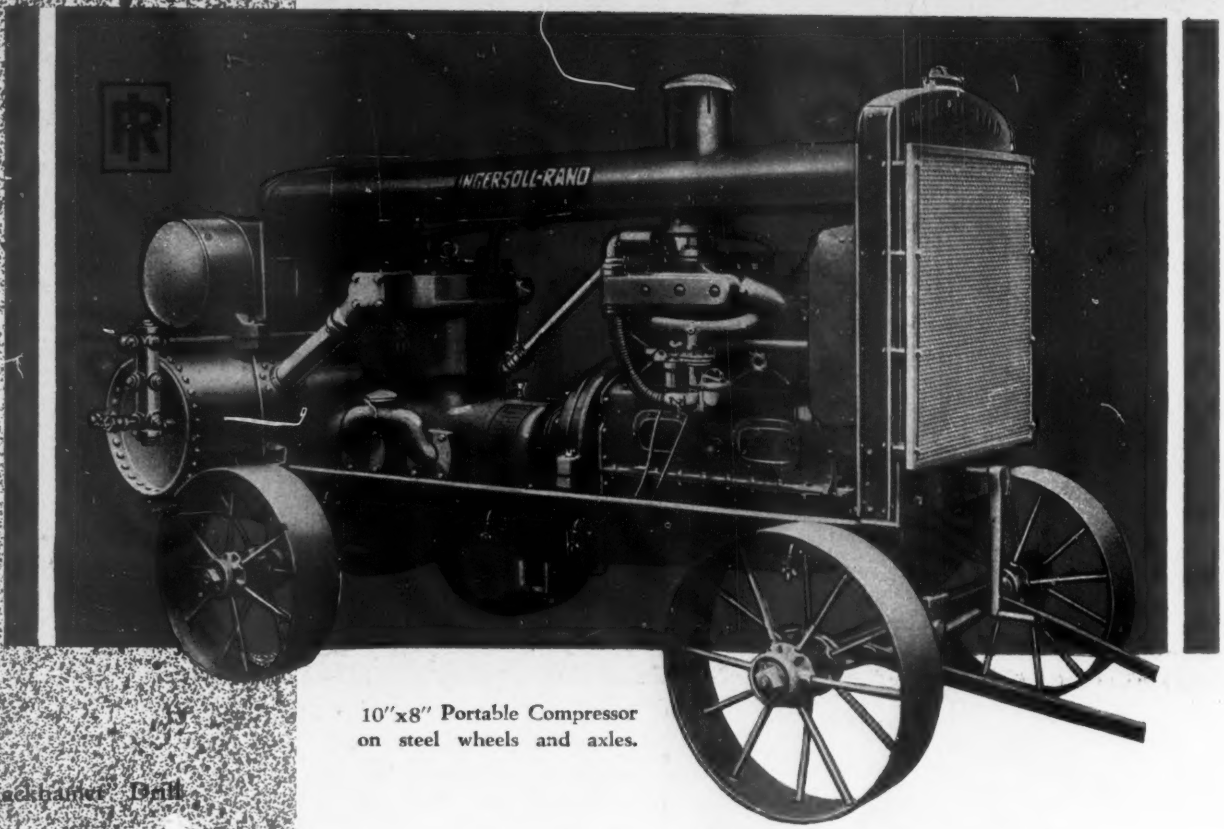

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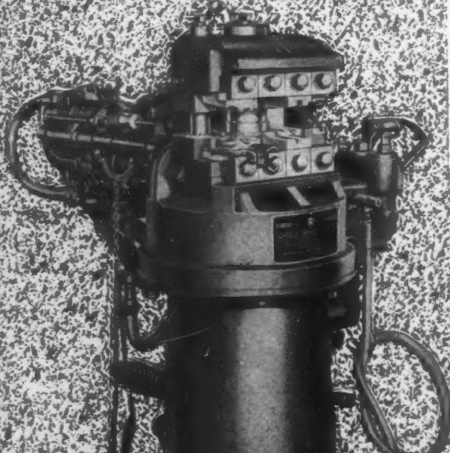
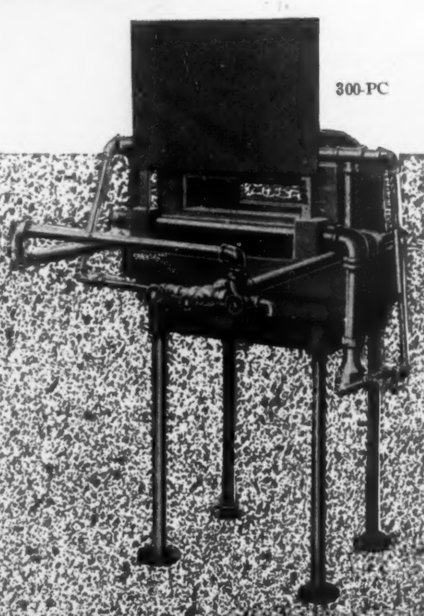


Right: CC-45 Paving Breaker

Right: No. 6F Oil Furnace



300-PC

As It Seems To Us

ROBERT G. SKERRETT RETIRES AS EDITOR

WITH the preparation of the editorial material for this issue, ROBERT G. SKERRETT has concluded almost ten years of active service as editor of *Compressed Air Magazine*. We feel certain that our readers will agree that in those ten years the publication has gone steadily forward in point of both its usefulness to industry and its general interest to the person who reads primarily for pleasure. We are glad to state that Mr. SKERRETT will continue as one of our contributors.

PRICE OF ENGINEERING PROGRESS

HOW to dispose of Muscle Shoals Development has been something of a political football ever since that costly governmental undertaking was completed. Whether the power plant and the two associate plants for the fixation of atmospheric nitrogen should be operated by the Federal authorities or leased to private enterprises has been the subject of well-nigh continuous discussion. The propriety of one or the other course does not concern us at this moment. The outstanding point of interest is the present economic value of the two nitrate plants as summed up by a commission that has lately reported upon Muscle Shoals.

It will be readily recalled by the public that United States Nitrate Plant No. 1 and United States Nitrate Plant No. 2 entailed the expenditure of many millions of dollars—outlays that were generally thought to be warranted when the stress of war demanded great quantities of fixed nitrogen for the manufacture of high explosives. One of the two plants was admittedly an experiment on a vast scale, although based upon research that seemed to promise much. According to the recent official report, the situation today is this:

"Plant No. 1, the first direct synthetic ammonia plant to be built outside of Germany, is too faulty to be of any possible value, and is not necessary or suitable for experimental purposes. Plant No. 2, designed to make cyanamide, was considered the best of its kind in 1918, but subsequent developments in the nitrogen industry, together with improvements in the cyanamide process, have largely destroyed its value. In view of these conditions, Muscle Shoals seems to possess at this time only meager economic possibilities for the production of nitrogen".

It must not be imagined for a moment that our demand for fixed nitrogen has diminished. In fact, it is steadily on the increase because of the multiple uses to which fixed nitrogen is put today. Our total production in 1918 amounted to 78,236 tons, while the domestic output in 1930—the latest year for which we have returns—was substantially 304,000 tons. It is significant that more than half of this was supplied by gas works and by-product coke ovens, while 140,000 tons was produced in eight plants engaged in the fixation of atmospheric nitrogen. These plants have come into being since the plants at Muscle Shoals were placed in reserve, and, therefore, have profited by various advances in the art.

While the obsolescence of the two plants at Muscle Shoals is primarily a cause of regret, on the other hand their status is an indication of how far we have gone forward in the meanwhile—in short, it is the price we must inevitably pay for engineering progress. In no other way could we keep abreast of achievements elsewhere and not only maintain the strength of our position in competitive effort but assure our industrial well-being.

IT PAYS TO ADVERTISE

PUBLICITY of a well-directed sort is indispensable to the promotion of business—using that term in its most comprehensive meaning. Emphasis was laid on this a short while back by the PRINCE OF WALES, who delivered himself of the following jingle at a meeting of the Travel Association of Great Britain:

"Early to bed and early to rise—
You'll soon be busted if you don't advertise".

This parody of a Mother Goose rhyme contains a wealth of wisdom, and should be pondered carefully by those responsible for the advertising budgets of all concerns that must make their first appeal to customers through the medium of pictures and printed words. England's royal salesman is wise in his generation and alive to the existing opportunity.

DEPARTMENT OF COMMERCE IN NEW HOME

THE architectural dignity of Washington City has been increased by the completion of the new building that will henceforth house the nation's many-sided Department of Commerce. Beneath the roof of this imposing structure will be accommodated a personnel numbering 5,000. This massive edifice is supported on reinforced-concrete piles because of the nature of the underlying ground; and if these piles could be placed end to end they would extend a distance of 80 miles. The structure contains 3,000 and more rooms; and nearly six acres of glass was required in glazing the building's 5,200 windows.

From our point of view nothing is more interesting about this monumental home of the Department of Commerce than the diversity and the quantity of stone used in its construction—the material originating in many states. In this work the air-driven rock drill performed an essential service. The following particulars concerning the stone were recently made public by the *New York Sun*: "Among such materials are 2,000 carloads of limestone from Indiana; 150 carloads of granite quarried in Connecticut and sawed, cut, and milled in Massachusetts; 900 tons of marble from Missouri; 470 tons of marble from Vermont; and 860 tons of Mankato stone from Minnesota".

The new Department of Commerce building is one of an extensive group that will eventually occupy the Mall, which reaches from the Capitol grounds westward to the Potomac River. It is one more step in the transformation of the south side of Pennsylvania Avenue, which has been for many years flanked by architecturally unlovely and even shabby structures. When the scheme of beautification becomes an accomplished fact, then the nation's Capital will, indeed, be a strikingly impressive governmental center.

LIFTING GRAND CANYON WATER THREE THOUSAND FEET

SPRINGS near the bottom of the Grand Canyon of the Colorado are to furnish water to tourists visiting a resort located on the southern rim of that great chasm. The question of a supply of potable water has been a pressing one for some time; and a contract has been let to a Los Angeles firm which will soon begin the laying of nearly two miles of 5-inch pipe from the springs to the rim of the canyon, 3,075 feet above. The piping will be laid along the extremely precipitous rocky wall of the gorge; and the work will, undoubtedly, prove both difficult and dangerous. By the terms of the contract, the project must be completed within a period of four months from the beginning of operations.

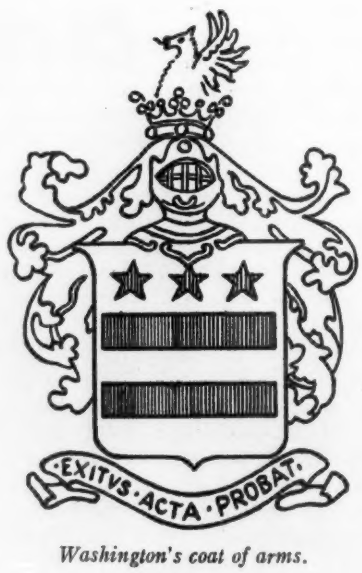
According to a news item, the water will be raised straight up to a height of more than half a mile, and a number of multi-stage, electrically driven pumps will be installed for the purpose. The resort that will obtain its water supply in this manner has been established at the present site for a goodly number of years, and since then all its water, so it said, has been shipped in by tank cars from sources 100 miles away. The new arrangement will obviate some uncertainties and will be typically up to date in all of its engineering features. Every precaution is being taken to insure a continuous flow of water from the springs to the reservoir at the canyon rim.

A Bicentennial that Should Encourage and Inspire—

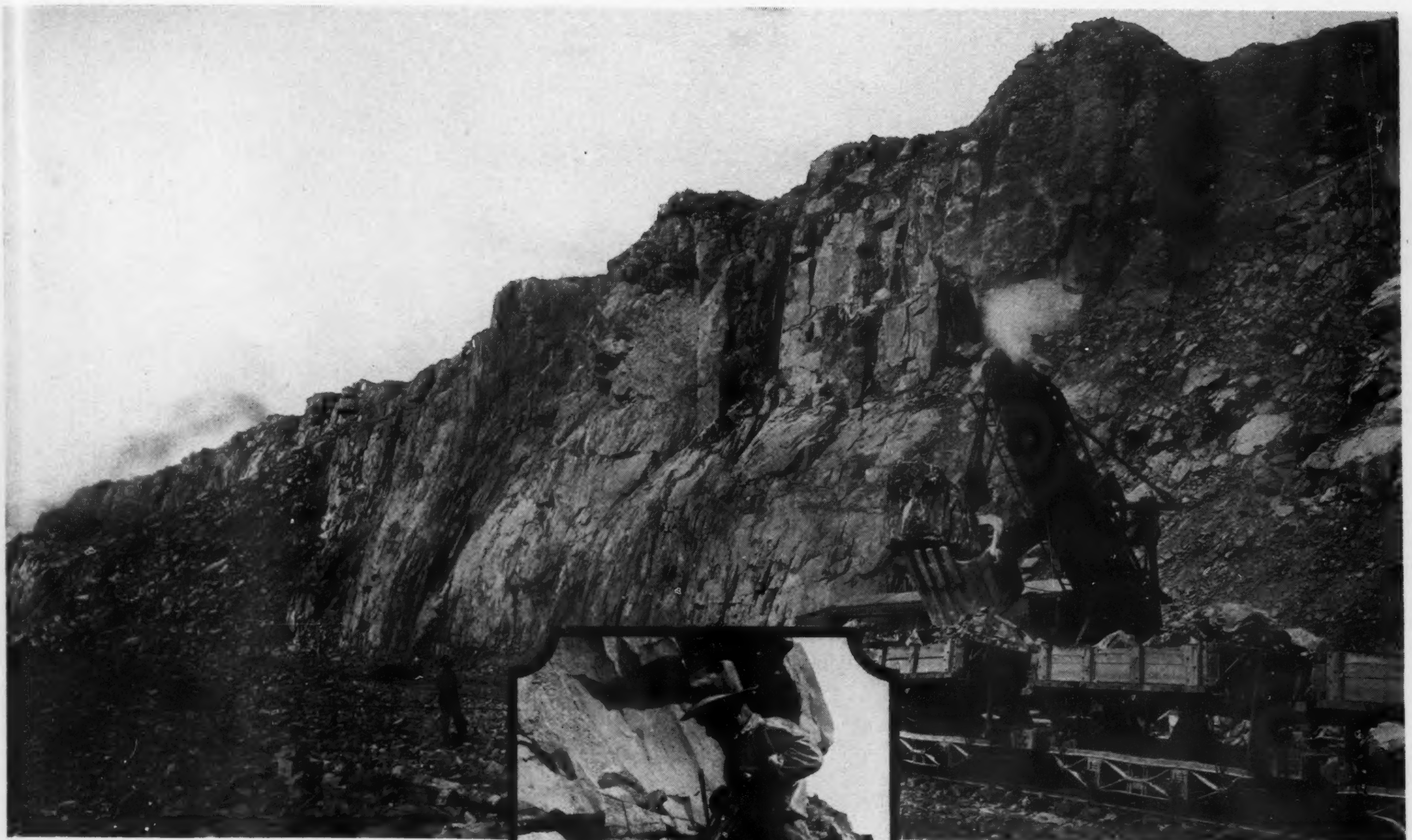
George Washington was born on the twenty-second of February, two hundred years ago, in an humble home at Bridges Creek, Westmoreland County, Va. On December 14, 1799, Washington died at Mount Vernon, with the whole nation bereaved because of his demise. It is, therefore, befitting that we, who owe him an incalculable debt, should now pay whole-hearted tribute in commemorating the bicentennial of his birth.

In this homage, don't let us be content merely to recall, as our histories tell us, that he was: "First in war, first in peace, and first in the hearts of his countrymen". Neither let us be content to recall only the glamorous moments of his career. Let us, instead, familiarize ourselves with his spirit of self-sacrifice that urged him to lead the Continental forces to victory through years of stress, even privation, against seemingly overwhelming odds. Let us keep before us how he patiently endured vituperation during his two terms of the presidency so that he might transform a federation of jealous states into a union that could command the respect of the whole world.

Washington was a man of vision and possessed of an amazing capacity for work and constructive effort. These he employed without stint. The leaders of today can learn much and gather inspiration from the way Washington met the national problems of his period; and the populace, too, should know how he faced his grave hours as well as his bright ones. That knowledge will not only add to their conception of George Washington's stature but it will hearten all of us in dealing with the tasks that now confront us. George Washington had confidence in the generations that would follow him here; and it is for us to prove that we are worthy of that faith.



Washington's coat of arms.



Quarry With Mile-Long Face

By R. G. SKERRETT

THE New Haven Trap Rock Company was organized in 1914 for the purpose of developing and operating a quarry at Totoket Mountain, North Branford, Conn., ten miles northeast of New Haven. The company acquired a large tract containing about 500 acres of quarry land. D. A. Blakeslee, president, and Clarence Blakeslee, treasurer, were the prime movers in this undertaking. Alexander McKernan, an experienced quarryman who had been connected with other enterprises of the Blakeslees for many years, was selected as superintendent. Construction was begun at once. Mr. McKernan and his helpers worked so effectively that it was possible to start quarrying operations in the spring of 1915. Mr. McKernan has continued as superintendent ever since, and he has played an important part in the progressive development of this large and successful quarry.

As the years have gone on, newer and more numerous equipment have been introduced, and quarrying methods have been altered as gains in economy and efficiency could thus be realized. These betterments have contributed to larger output and lowered cost of production, and, incidentally, have been the means of extending the markets of the company's stone.

The backbone of the hill upon which the quarry is located is a great upheaved mass that is reputed to be the purest trap rock anywhere east of the Rocky Mountains. Be this as it may, there is no disputing the fact that the rock is notably hard, close grained, and excellent for all the services to which such material is now put. Trap rock, as is well known, owes its characteristics to its igneous origin. According to an analysis made by the United States Department of Agriculture, the rock quarried at North Branford is a fine-grained, dark steel diabase, composed essentially of plagioclase and chloritized augite, as follows:

Silicate of lime, magnesia, iron, alumina	41.8%
Silicate of alumina, lime, soda	41.8
Accessory mineral—magnetite	3.9
Secondary minerals—chlorite	9.5
kaolin	3.0
	100.0%

The floor of the quarry is on the south side of the hill and something like 100 feet above the office and some of the plant buildings; and the present face is 100 or more feet back from the edge of the plateau, which has been successively deepened and lengthened as the quarry has been extended. The quarry face has thus receded northward as more and more rock has been brought down; and it now covers, from east to west, a distance of substantially a mile. At its highest point the face rises 100 feet above the floor. Viewed from the valley below, the quarry appears as a rocky palisade crowning the hill which overlooks a broad and picturesque valley.

During the early years, the practice at the quarry has been to maintain a face consisting generally of two benches—each bench being approximately half the height of the face. Where this method is still in use, the down holes on the benches are, as in the past, sunk with well drills—the holes being spaced longitudinally 25 feet apart and generally about 35 feet back from the face. This work is done with Keystone and Armstrong well drills. The toe holes or snake holes at the bottom of the face are drilled with X-70 and X-71 drills—the holes being about 30 feet in depth and spaced on an average of 6 feet apart.

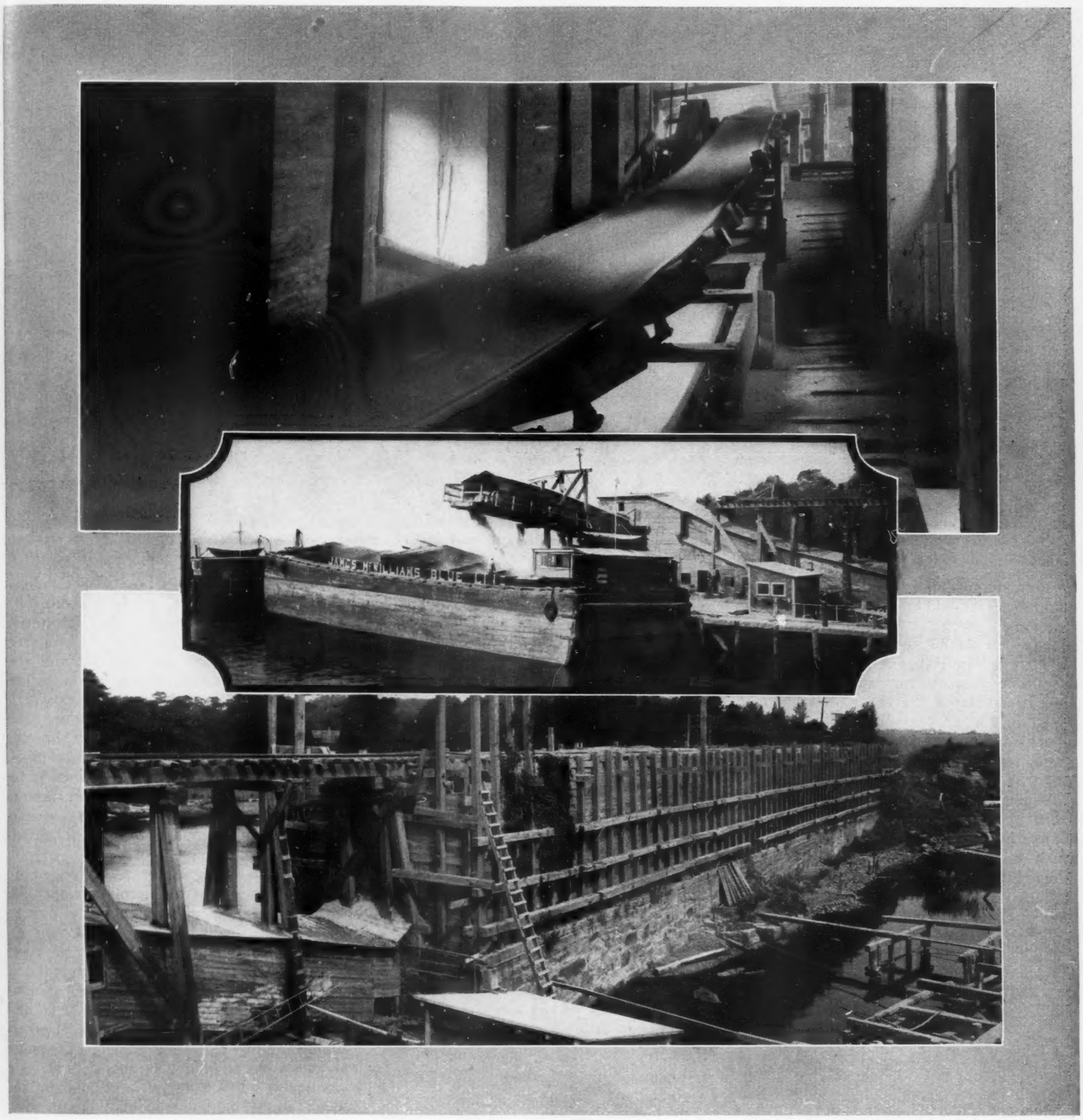
A departure from this procedure was introduced early in 1930, when the tunnel method of blasting was given a trial at one point on the face. The outcome was so satisfactory that Mr. McKernan resorted to it a year later in two large blasts consisting, respectively, of two tunnels and three tunnels. The two shots brought down a total of something more than 500,000 tons of shattered rock—the explosive used in all five tunnels amounting

Top—General view of crushing plant and screens at North Branford. Center—One of the X-71 drills engaged in drilling a line of snake holes at the bottom of the quarry face. Bottom—Train of laden 12-yard dump cars arriving at the storage yard six miles from the quarry.

to 109,400 pounds of 40 per cent dynamite. In the case of the 3-tunnel shot, owing to the massiveness of the rock directly above the base of the face, about 90 snake holes were drilled along the bottom to a depth of 30 feet. The charges in the snake holes and the unit charges in the crosscuts or wings of the tunnels were exploded simultaneously. The results obtained with tunnel blasting confirmed Mr. McKernan in his belief that the method could be adopted as standard practice; and he is now engaged in clearing away the last benched section of the quarry preliminary to using tunnel blasting mainly in the future.

The tunnel driving has been done with Ingersoll-Rand mounted "Jackhamers"; and this type of rock drill will be employed henceforth when the tunnel-blasting method becomes standard practice throughout the whole length of the face. The fact that the face of the quarry is so long and is 100 feet and more above the base of the hill where the machine shop is located would entail the expenditure of much time and labor in the handling and reconditioning of drill steels had Mr. McKernan not outfitted a box car to serve as a mobile blacksmith shop. This plant has justified itself in the fullest sense of the term and has proved not only a convenience but a means of saving much energy and money.

The box car is equipped with a No. 50 Ingersoll-Rand sharpener, a No. 25 I-R oil furnace, a coal-fired forge, and an anvil. It can be moved close to the point where the rock drills are operating so that the steels do not have to be carried more than 100 feet to

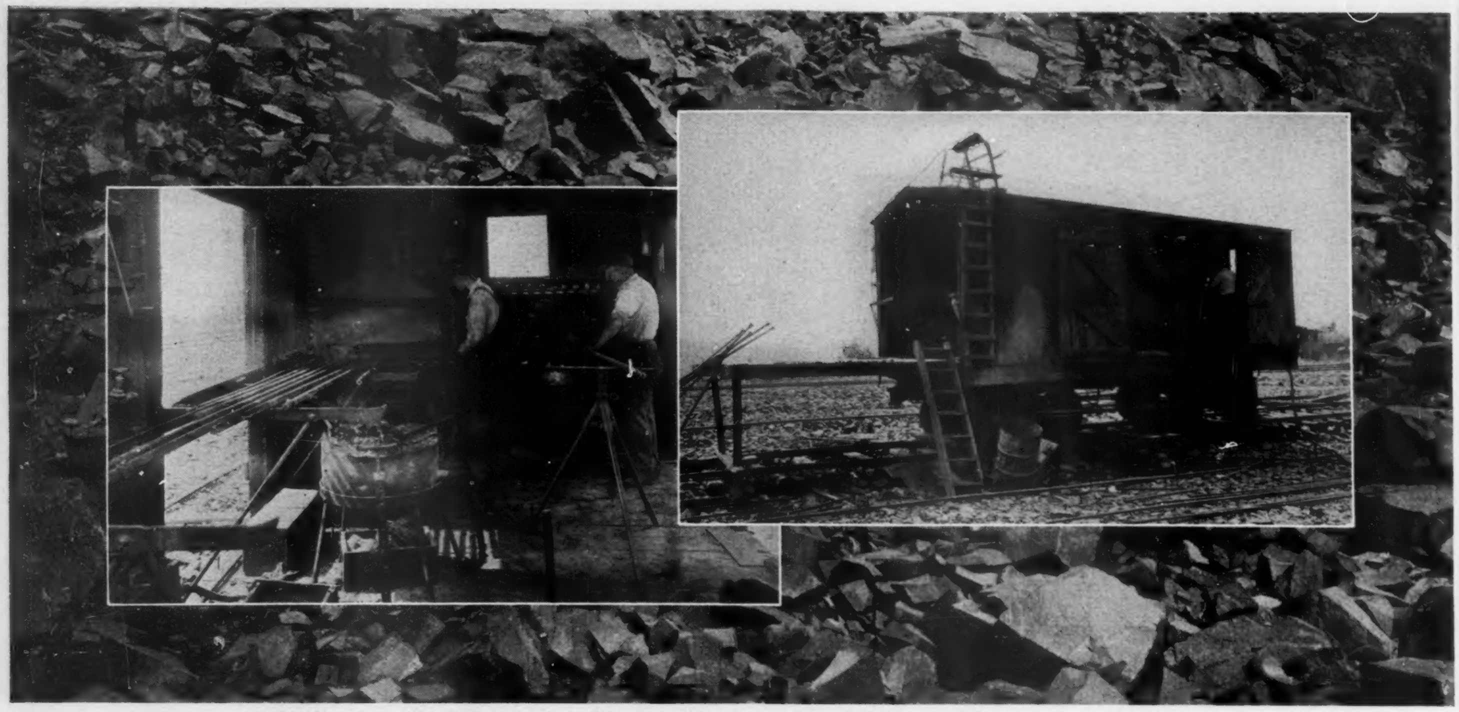


Top—The 30-inch belt conveyor at the dock of The New Haven Trap Rock Company. Center—Loading barges with trap rock for distant transportation. Bottom—Storage bins above conveyor system by which trap rock of any size or mixed sizes can be delivered to barges for loading.

and from the blacksmith shop. A supply of conditioned steels is maintained for the drill runners; and the steels are laid out near the workers. Inasmuch as compressed air must always be available for the rock drills, the same air line can be drawn upon to furnish air for the sharpener and the oil furnace. It is easy to grasp how such a blacksmith shop fits admirably into the routine needs of this North Branford quarry; and what Mr. McKernan has done in this respect might profitably be adopted by some other operators.

The blasted rock is loaded by steam shovels into 6-yard Western side-dump cars which are hauled by steam locomotives to where the rock is dumped into the bin feeding to the first of the crushers. From that point to the last of the crushers the flow of the material is by gravity. The rock is first fed to a 48x72-inch Buchanan jaw crusher. From that unit the stone goes to a No. 10 Allis-Chalmers gyratory crusher, and thence is delivered to a 7-foot Symons cone crusher. This is the regular sequence. At times, however, it is found advisable to run the rejects from the 7-foot cone crusher through four Symons disk crushers. This is done when it is desirable to increase the percentage of small stone.

The stone from the last crusher is carried by a belt conveyor up a 20° slope to the top floor of the neighboring screening plant. This belt is 209 feet long between centers. There the stone is separated into five different sizes. At the screening plant the products are delivered from the several bins into 12-yard



Well-equipped mobile blacksmith shop that has proved highly efficient and economical.

Western dump cars or into 50-ton bottom-dump steel cars, and are then hauled by steam locomotives down the line for a distance of six miles for shipment either by rail over the New York, New Haven & Hartford Railroad or by water from the company's own dock on Long Island Sound. Surplus stock is dumped for storage in an open-air yard that has a capacity in excess of 75,000 tons. All tracks are of standard gage; and the hauling in the quarry is done by 35-ton locomotives while the trains that go to the storage yard are pulled by much larger locomotives. In the quarry there are three Marion steam shovels which are equipped with crawler traction.

With the exceptions of the steam locomotives and the steam shovels, electric drive is provided for the well drills, the crushers, the screens, and the machinery in the repair shop. This has made for operating economy, and has obviated the handling of a large amount of coal annually. The quarry and the associate crushing and screening plant turn out in the course of an average working day 4,500 tons of stone; but a record has been made of 5,062 tons in a day. The working month consists usually of 25 days; and during such a period the North Branford quarry has produced 100,000 tons or better.

At the dock on the waterfront the cars dump into a series of bins that hold the different-sized products. Beneath this long line of bins there is a 30-inch Robins belt-conveyor system. This conveyor receives stone of any designated size or all sizes, if a mixture be desired, and carries it to another conveyor on the dock which discharges into the holds of barges spotted below it.

The compressed air required for various services in the quarry is furnished by two XRE-2 compressors. Each of these machines is an 18&11x14-inch unit, and has a piston displacement of 1,052 cubic feet per minute. Air from the compressors goes to two VM Type aftercoolers and thence into receivers. The aftercoolers make it practicable to deliver moisture-free air to the drills and to other pneumatic equipment in the quarry. It is well known that dry air makes for operating economies and reduces wear and tear on tools. Furthermore, air so conditioned is especially desirable where it is distributed through long lines of pipe exposed to the low temperatures of the winter season. Work at the quarry of The New Haven Trap Rock Company is carried on for the better part of the year; and the quarry lies in the sweep of northerly winds.

The quarry boasts an unusually well-equipped machine shop which is amply able to handle almost all repair work required in the maintenance of the mechanical features of the plant. It is an exception when outside facilities have to be called upon. Its personnel, including management, numbers about 110; and this force constitutes a very interesting part of the successful operation of the quarry. The labor turnover is virtually nil; and this happy state of affairs is due to the broad-minded understanding and the sympathetic way in which all personnel questions are dealt with. The organization is, in effect, one big family held together by the recognition of the fact that the welfare of the individual is for the good of all. This spirit has been inspired and encouraged by Mr. McKernan not only during working hours but during the periods of relaxation.

There is a clubhouse at a convenient location on the company's property, and this is furnished so that it can be used for dances, for card parties, and for other indoor diversions. Something is going on in the clubhouse well-nigh every night weekly; and it is at the disposal of the men of the organization as well as their wives and children and other relatives. Indeed, this place of entertainment draws to it the town people generally as guests of the quarry personnel; and, as a consequence, it is a sort of focal point for the whole social life of the small community. In addition to the clubhouse there is a large recreation field, including a baseball diamond, a football gridiron, and facilities for other outdoor sports. One can readily imagine what this does in the way of promoting close fellowship among the employees of The New Haven Trap Rock Company.

The Athletic Club maintains a baseball team, a football team, and a basket-ball team. The baseball team has won the championship for two consecutive years of what is known as the Shore

Clubhouse for employees maintained by The New Haven Trap Rock Company.

The two Type XRE compressors that furnish air for rock drills and other pneumatic equipment.

Line League, which takes in eight towns; and the basket-ball team has won the championship of the county YMCA League. Once every year the men of the quarry stage a clambake, somewhere on the neighboring Long Island shore, at which everything worth eating is to be had. These clambakes are thoroughly enjoyable affairs but a trifle too boisterous for participation in by the feminine members of the families concerned. Pleasures for the women are provided at other times and in other forms.

The administration of the quarry shows again how kindly leadership makes for successful results in both business and human relation. The age of machinery has not lessened one whit the need of this contact between a superintendent and his men. The corporation's officers at the present time are D. A. Blakeslee, president; Clarence Blakeslee, treasurer; Albert D. Blakeslee, vice-president; George E. Hall, secretary; and William E. Hilliard, general manager.

LACQUER RECOVERED FROM SPRAY BOOTH FOR RE-USE

By E. E. Halls

THE writer has read with great interest the article in the November, 1931, issue of *Compressed Air Magazine* which describes a very simple procedure for reclaiming waste nitro-cellulose lacquer. Cellulose products offer the big feature of quick drying with the consequently rapid handling of work; and spray application—automatic, in many cases—is the only satisfactory method in general use. At the same time, the enormous loss of lacquer has been a troublesome point that to date has not found a universal solution: one has had to be content that the heavy raw-material loss is more than offset by the other advantages just mentioned.

The means of collecting the scrap in the process of reclamation referred to is one of very simple performance, and the operations of recovering it in a usable form are distinctly ingenious. Publishing details of the practice is to be commended, because they call attention to the possibilities of the procedure and to the need of effective control and suitable equipment. The economies of reclamation might well be studied by works large and small, as, probably, layout of finishing operations and multiplicity of types of lacquer are determining factors rather than consumption, alone. Some of the limitations and disadvantages, however, are worthy of note.

Recovered lacquer, no matter how well cleaned, can hardly be relied upon for uniformity of color and appearance, and for lightness of shade in comparison with the original standard. Again, in the solvent treatment, it is to be expected that some of the softening agents, resinous or oily in character, will be removed. With controlled recovery, these shortcomings can to some degree be eliminated, but they cannot be fully corrected without much elaboration that would probably offset the savings. In other words, the use of the reclaimed product demands considerable thought if it is to be applied to first-class work, for which adherence, flexibility, and durability are paramount qualities and for which extensive exposure tests on trial-coated panels are warranted. On the other hand, in many instances, its use is justified without investigation apart from initial workability.

In this category of jobs should be classed all kinds of work requiring only a temporary hard-film protection to safeguard it during short-period storage or while handling during assembly. Thus on many mat-nickel and zinc-plated articles could the recovered lacquer be economically employed. It is noted that the process is suitable for application to clear-cellulose lacquers only, and not to the more expensive pigmented varieties. The problem of extracting dirt from pigment and of re-incorporating pigment are something of an obstacle.

In modern mechanized works the tendency is not to segregate processes in separate departments but to attain a flow of production from raw material to finished product along a continuous chain of operations. One thus finds the compressed-air system and spray booths introduced into assembly lines. This adds to the difficulties in collecting waste lacquer, particularly as the practice reduces the possibility of segregating each type of lacquer or enamel to its own booth.

In conclusion, reference may be made to the allied industry of ceramic glazing and enameling, where it has long since been the recognized practice in small-scale works to salvage the materials from the coating benches. There, however, the beauty of an object is often mainly related to an unexpected coloration or discoloration.

PORTABLE MINE FLOODLIGHT

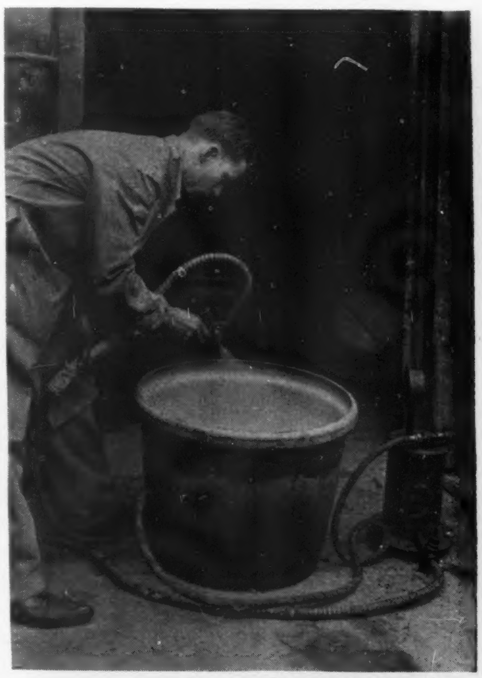
A PORTABLE floodlight for mine use has been developed in the year past on which the United States Bureau of Mines is said to have placed its stamp of approval. The lamp weighs about sixteen pounds, and consists of a neat metal battery case, with a handle, on the cover of which the reflector is mounted so that it can be turned in any desired direction. A reflector with a mat or a polished surface can be provided, the former giving a beam candle power of 400.

The difficulty of providing a floodlight sufficiently powerful and yet safe has, according to the manufacturer, been overcome in the bulb mounting which is such as to obviate danger even in the event the bulb should break while burning in an explosive mixture. Current is supplied either by six Model E or four Model G Edison batteries. The bulb takes four times as much power as the ordinary electric cap lamp and gives eight times as much light for a burning period of from 8 to 8½ hours. The floodlight is recommended by its makers for use in gaseous workings and in powder magazines.

SURFACING METAL WITH RUBBER BY AIR SPRAY

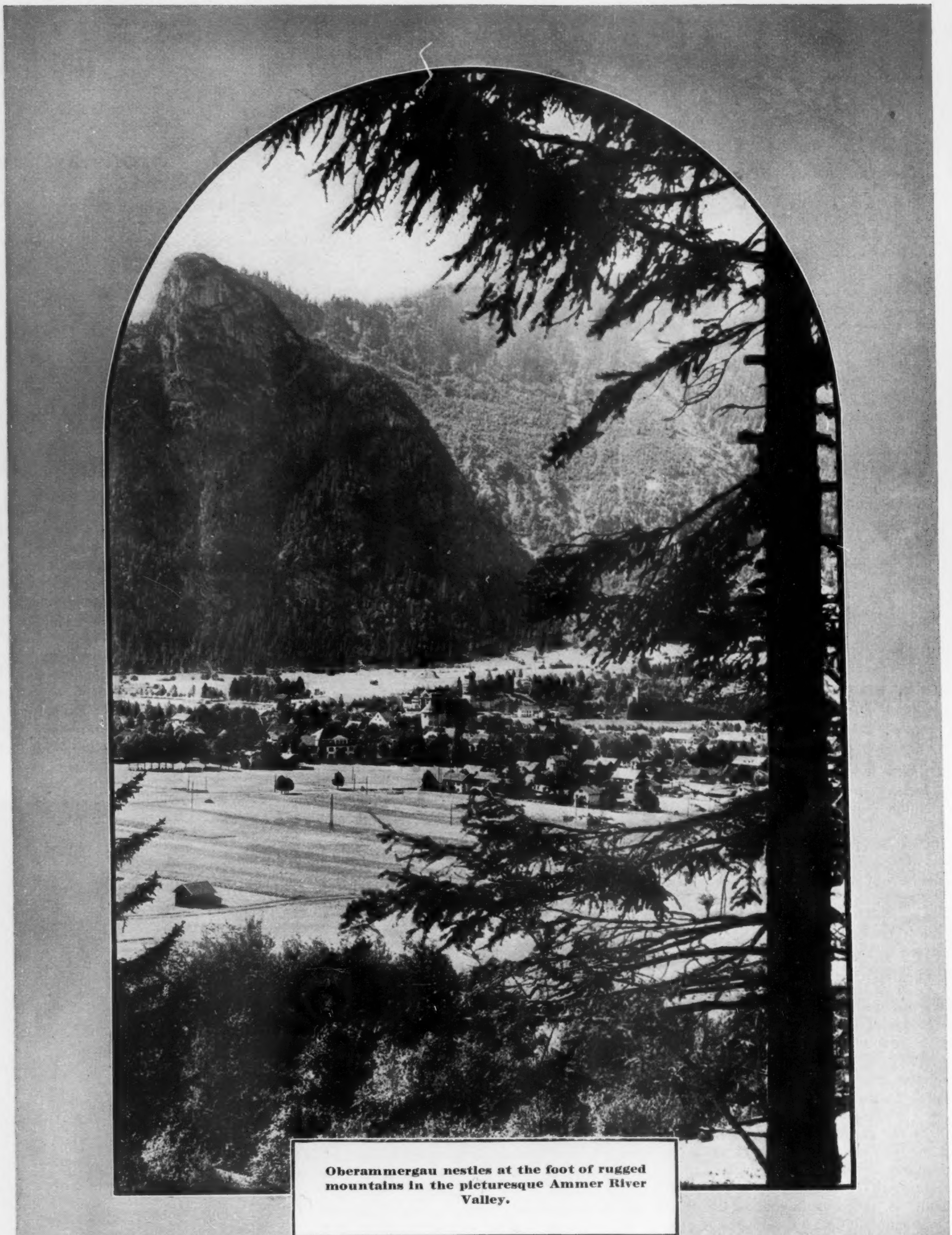
THE availability of rubber latex, the form in which it is now largely shipped from the plantation to the consumer, has revolutionized the art of lining and covering utensils, parts, and fittings of all sorts for the chemical engineer with that protective material. The work is being done variously by dipping and by what is known as electrophoresis—a process which, however, cannot yet be said to have reached a commercially successful stage.

Among the manufacturers who have taken the lead in this branch of industry is Nordac, Ltd., of Harrow, England. This firm has specialized in lining and coating equipment with soft rubber, and has developed a system of applying the latex by an air-operated spray gun. For this purpose the latex, which is stabilized with ammonia, is mixed in a mill with adhesives, accelerators, sulphur, curing agents, and pigments, depending on the service to which the articles treated are to be put. To insure a perfect bond, all metal surfaces are first freed of dirt and rust by sandblasting or other suitable means. Coatings or linings, varying in thickness from $\frac{1}{32}$ to $\frac{1}{16}$ inch are built up quickly—as many as eight films being applied with short drying intervals between successive layers. With the spraying finished, the rubber is vulcanized by what is said to be a simple but effective method.



Courtesy, The Industrial Chemist

Spray gun applying rubber latex to the inner walls of a container used abroad for shipping hydrochloric acid.



Oberammergau nestles at the foot of rugged mountains in the picturesque Ammer River Valley.

Ewing Galloway, New York

The towering Zugspitze viewed from the shore of the scenically located Eibsee.

Ewing Galloway, New York

Mountain Railway Built for Oberammergau Visitors

This Bavarian Railway Makes Accessible the Top of Germany's Famous Zugspitze

By ROBERT PEER

OBERAMMERGAU and the Passion Play are inseparably linked in the minds of most people, and yet a very large part of the populace does not know why there is this association. It will, therefore, not be out of place to touch upon the reasons for this relationship while describing a recently completed railroad that was built to serve especially the great influx of visitors drawn to Oberammergau every ten years and to add to the pleasure of other tourists in the meantime.

Oberammergau dates back to medieval days; and for centuries its citizens have devoted much of their energy and talent to the carving of crucifixes, rosaries, and images of saints, and to the making of wooden toys and kindred articles—some of the craftsmen having contributed notable examples of their skill to far-away churches and to other religious institutions. But it was not until the world generally learned of the Passion Play periodically enacted in that Bavarian village that the place assumed a wider and deeper significance.

This ancient community lies on a route traced by Roman soldiers and tradesmen bound to and from the shores of the Mediterranean 1,000 or more years ago. It is situated about 45 miles to the south and west of Munich and in that section of Germany known as Upper Bavaria. The village is set in the picturesque Valley of the Ammer River, and is nestled among the foothills of the Alps. The region is one of great scenic beauty; and it is not hard to understand how the simple-hearted people of Oberammergau, in their comparative isolation, have responded with a marked intensity of feeling to the spiritual appeal of life. The vastness of nature's upheaved surface, the awe-inspiring magnitude of the surrounding mountains, and the introspective tendency of most human beings in such an environment, made them peculiarly ready to turn with unquestioning faith at a time of extraordinary distress to their Supreme Master for relief—promising perpetual evidence of their gratitude if relief were granted.

In 1632, Oberammergau, with other sections of Bavaria, was swept by the plague; and between the autumn of that year and July of the succeeding year no fewer than 84 persons succumbed to the dread disease. The community at that time numbered scarcely 600 souls. Appalled by the ravages of the scourge, and fearing lest it would not cease to take dire toll until all were stricken, the villagers pledged themselves to give a Passion Play every ten years if the hand of Death were

Center—The heavy white line and the dotted section indicate, respectively, the open and the tunnel divisions of the Bavarian Zug at Adit No. 1. Bottom—Carting dismantled po

stayed. After the making of that solemn vow, so tradition has it, no more of the inhabitants died of the plague.

The original form of the play is attributed to the Monks of Ettal, who dwelt in a monastery situated a little higher up in the valley and founded by Emperor Ludwig IV, the Bavarian, in the first half of the fourteenth century when returning, at the head of his army, by way of the Alps from Rome. Undoubtedly, the text was modified in the course of succeeding decades; and the form of the play was carefully revised by the parish priest of Oberammergau early in the nineteenth century. Music for the dramatization was composed by the village schoolmaster, one Rochus Dedler, in 1814.

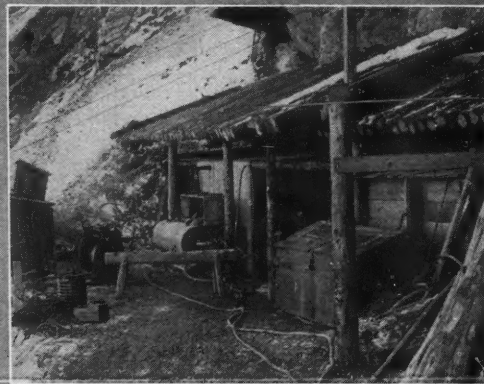
The first Passion Play was given in 1634; and since then the presentation at regular intervals has been deemed a sacred duty. Performances followed regularly every ten years after that date up to 1674; but beginning with 1680 and thereafter the play was staged each decade with the exceptions of 1811, 1815, 1871, and 1922, when for certain reasons it was produced in off years. Thus, for substantially three centuries, the pledge has been kept that was made when the people of Oberammergau feared their extinction. For more than 200 years of that span the giving of the play entailed a heavy monetary loss, which was met without murmur by the community and the church.

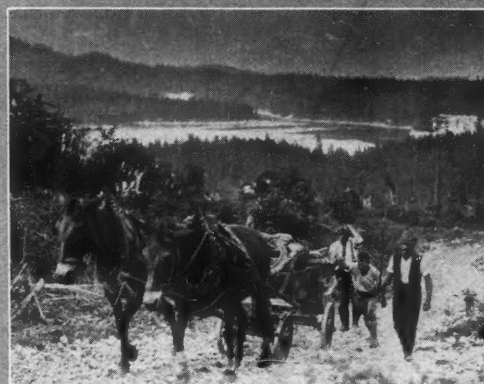
As early as 1840, attendance at the Passion Play had become so large that the existing theater, capable of seating several thousand persons, was too small for the purpose. Emperors, kings, and princes found themselves guests in the Bavarian village side by side with humbler folk who had journeyed from all over the world to witness the unique spectacle. That situation led to the construction of an open-air theater that could accommodate a greater number. After the World War the theater was again rebuilt upon a more elaborate scale, and it can now seat an audience of considerably more than 6,000.

In 1900 the visitors to the Passion Play were in excess of 200,000; in 1910 the attendance was more than 260,000; and in 1930 the combined audiences numbered 300,000 and more, of which 50,000 were from the United States. In the years prescribed, the Passion Play is given during the months of May, June, July, August, and September on every Sunday and holy day, with two exceptions, and also every Wednesday from July 1 on to the middle of September. Each performance begins at 8 a.m. and ends at 6 p.m., with an intermission of two hours in the middle of the day. There are 55 principal characters, a choir of 45 and two soloists, and an orchestra of 50 pieces. With the supernumeraries—impersonating soldiers, crowds, etc., the total stage personnel is something like 700. For some time now the Passion Play has made rather handsome returns upon the outlays; and, after meeting all expenses, the surplus is devoted to the good of the community.

The principal parts are commonly hereditary in certain of the village families; and assignments for these parts are made with due regard to the moral character of the actors and to their dramatic ability. The inhabitants look upon the Passion Play as an act of religious devotion, and they strive reverently to portray the biblical characters they are called upon to impersonate. In this they are carrying out communal tradition; and because of this spirit the Passion Play as given at Oberammergau is one of the greatest and one of the most artistic spectacles to be seen anywhere. No wonder the number of visitors drawn to the vicinity every ten years grows apace.

The average stay in Oberammergau of the Passion Play visitor does not exceed parts of three days; and, being in the midst of a mountainous region of much scenic charm, it is only natural that a very considerable percentage of these tourists should want to linger a while in the neighborhood to see some of the many points of interest in the countryside. One of these centers of attraction is Garmisch-Partenkirchen, the well-known and nearby Bavarian health resort. Beyond this noted community rise the towering crests of the Bavarian Alps, which are dominated by the famous Zugspitze that has an altitude of 9,738 feet—the highest mountain in Germany. The Zugspitze lies on the frontier between Austria and Germany; and just be-





Courtesy, Photogrametrie Ges. m.b.H., Munich

lway. Left, top—Cableway at Adit No. 1. Bottom—Electrically operated cableway at Adit No. 4. Right, top—Compressor house mpressors up a mountainside from the Eibsee.

fore the summer of 1930 a cogwheel railway was constructed that links Garmisch-Partenkirchen with the Zugspitze. This enabled visitors to the Passion Play to make without difficulty a trip into the glacial region of that mountaintop.

Only after years of preliminary effort was the concession for this railway granted by the Bavarian Government to the newly organized Zugspitzbahn Aktiengesellschaft, in Garmisch, founded by the Allgemeine Lokalbahn- und Kraftwerke, A.G., and the Bank Elektrischer Werke. The contract for the building of the line was awarded to the widely known Allgemeine Elektrizitaets Gesellschaft—familiarly called the AEG, of Berlin.

The Bavarian Zugspitze railway must be distinguished from the Austrian one, which was constructed several years ago and traces its route upon the Austrian side of the mountain. The latter is really an electrically operated aerial cableway, which is capable of transporting nineteen persons per trip and requires twenty minutes to reach the summit of the Zugspitze and to return to the starting point. The Bavarian line, on the other hand, is a regular mountain railroad that can carry 150 persons in each train. The Bavarian route has a length of about eleven miles. For 3.25 miles of the run it is a traction line, and from there on a cogwheel railway of which the first two miles has a maximum gradient of 11.85 per cent and the remaining longer stretch an average gradient of 25 per cent. At a height of 4,950 feet it enters a tunnel and arrives by a serpentine course at the uppermost station of Platt on the Plattach Glacier. The line followed by the railway is plainly shown in one of the accompanying illustrations—the dotted section indicating the route traced by the tunnel. The total length of the tunnel is just short of three miles; and in cross section it is 11 feet 4 inches in width by 15 feet 5 inches in height. The actual driving of the tunnel was done by an association composed of three firms, namely: Edwards & Hummel, A. Kunz A.G., of Munich; Wuerttembergische Elektrizitaets A.G.; and C. Baresel A.G., of Stuttgart.

The construction of the tunnel was started simultaneously at four points. These were: the lower portal at an elevation of 4,950 feet; Adit No. 1 at an elevation of 5,100 feet; Adit No. 3 at an elevation of 6,600 feet; and Adit No. 4 at an elevation of 7,200 feet. Adits Nos. 3 and 4 were located in the middle of the northern vertical wall of the mountain mass. Special preparatory work was necessary to provide access to these adits. This was required because of the steepness of the rocky walls and of the danger of avalanches of stone in the summer and avalanches of snow in the wintertime. Two Ingersoll-Rand portable compressors, 5½x5-inch Type 20's, were assembled at the foot of the palisade that rises almost sheer for 3,000 feet; and with the motive air furnished by those machines were operated pneumatic hammers that cut the climbing paths by which the otherwise inaccessible sites of Adits Nos. 3 and 4 could be reached. The compressors had been previously dismantled and the several parts packed on mule back up the mountainous approach to their working position at the foot of the rock wall.

Before tunnel driving could be started at Adits Nos. 3 and 4, the rock had to be cleared away at each place by drilling and blasting so that the tunnelmen could have a foothold to do their work. This blasting had to be done with the utmost caution; and in this manner an operating base was provided at each of the adits for a cableway station, quarters for the workers, and a chamber within which to erect stationary compressors. At Adit No. 3, the preparatory drilling was done while the portable supplying the necessary air was about 900 feet below. In the case of Adit No. 4, the compressor, after being dismantled, was hoisted 1,500 feet to that working site by means of a hand-operated winch. This was carried out as soon as the landing place at Adit No. 4 had been made ready. As the winch could not lift anything weighing more than 330 pounds, the task was made possible by hoisting the compressor piecemeal. At that height, 7,200 feet above sea level, one of the portables ran continuously, day in and day out, for four months, and the other unit was operated for a shorter period—neither giving the least trouble the while.

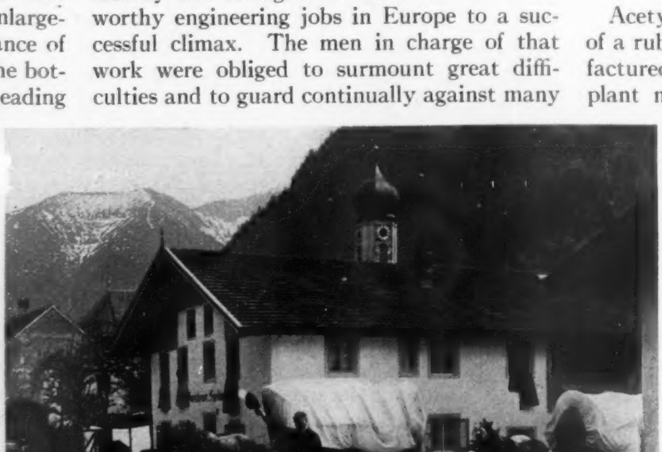
Ewing Galloway, New York
The theater at the edge of Oberammergau where the Passion Play was last performed.

When both compressors were at work at Adit No. 4, a fire occurred which interrupted activities for some time. The flames melted certain of the machines' brass and bronze fittings, but as soon as the damaged parts could be replaced it was possible to start the portables running again. They amply demonstrated that they could be counted upon to meet difficult conditions and to perform satisfactorily at high altitudes; and they showed how readily they could be transported to out-of-the-way places by lending themselves to quick dismantling and reassembling.

The tunnel was driven by first advancing a bottom heading of the full width of 11 feet 4 inches and 9 feet high, after which enlargement to full profile followed at a distance of approximately 300 feet to the rear of the bottom heading. Where the bottom heading was in soft rock it was driven with hand hammers; but when hard rock was encountered the driving was done with L-74 drifters mounted on vertical columns. The tunnel was advanced at an average rate of 16 feet every 24 hours. Something like six DU air-operated "Utility" hoists were utilized; and they did much good work. They answered admirably because of their light weight and the ease with which they could be shifted; and their air consumption was remarkably low.

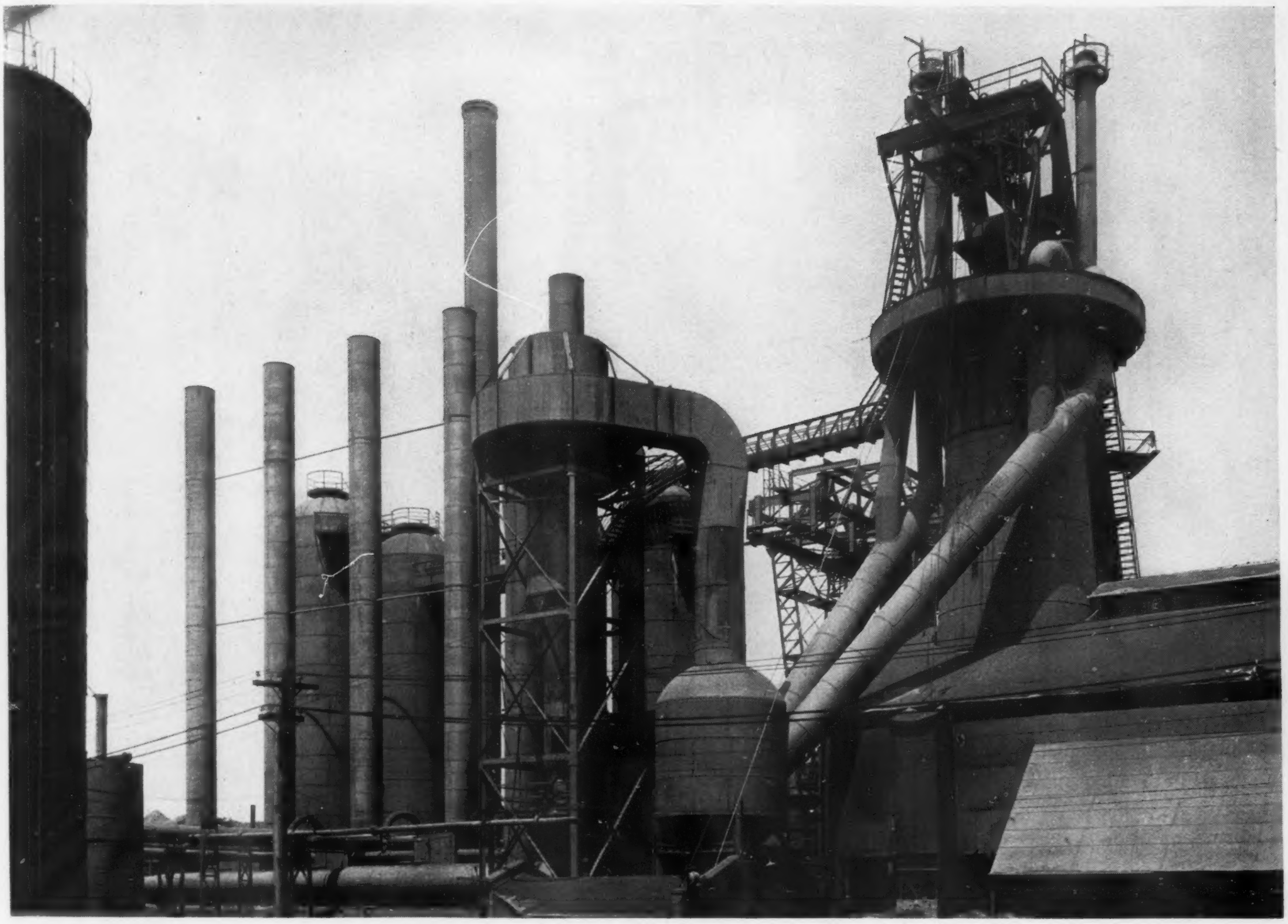
The last section of this system is, to be exact, not a railway but a cableway, and it extends from the Plattferner—the uppermost portal of the tunnel, which lies at an altitude of 8,000 feet—to the topmost station which is about 9,000 feet above the sea. In preparing the anchorage for the upper end of the cableway and for the site of the hotel that now stands there, a good deal of drilling and blasting had to be done. Even at that height, the portable compressor used to furnish air for the rock drills gave trouble-free service and greatly facilitated the rapid execution of the work. The hotel, which is typically modern and located at the summit of the Zugspitze, is capable of accommodating 400 guests.

The completion of the Bavarian Zugspitze railway has brought one of the most noteworthy engineering jobs in Europe to a successful climax. The men in charge of that work were obliged to surmount great difficulties and to guard continually against many dangers, not commonly encountered, owing to the exceptional heights and the steepness of the mountainsides. Rolling boulders and avalanches of stones were well-nigh daily occurrences; and care had to be exercised at all times to protect the workers, the machinery, and other equipment from the destructive onrush of those masses. In spite of the many obstacles and hazards, this technically very interesting railway was made ready for service within the really short period of two years; and that accidents were relatively few was due, in the main, to the foresight and the experience of the managerial officials.



Ewing Galloway, New York
A typical street scene in the heart of Oberammergau.

Acetylene, salt, and water are the basis of a rubberlike substance that is to be manufactured on a commercial scale as soon as the plant now being built for that purpose by the E. I. du Pont de Nemours & Company at Deepwater Point, N. J., is completed. According to a paper prepared by chemists of that company and read at a meeting of the American Chemical Society, acetylene made from limestone and coal is treated to obtain chloroprene which, in turn, is converted by a process called polymerization into a plastic material that has the characteristics of natural rubber. The new product is not claimed to be a substitute for natural rubber; but, because of certain qualities, has its own particular field of usefulness. In other words, it fits in where natural rubber is unsuitable.



MECHANICAL EQUIPMENT

of a Typically Modern Sheet-Metal Mill

By HUGH W. WRIGHT*

IRON and steel sheets have been rolled for more than 150 years by laboriously passing a heated piece of metal back and forth between revolving rolls. In fact, the old hand-finishing process employed in making wide thin sheets is still in use in all the mills of the world except those of the American Rolling Mill Company and those that operate under an Armco license.

The lifting of the burden from man's shoulders of what was probably the hardest and most grueling labor and transferring it to reliable, smooth-running machinery was not an easy task. It required faith, time, and money. Many years were spent in experiments to determine whether the plan was feasible before a single blue print was made. Then came more extensive experimenting by Armco's special engineers. Scientific instruments had to be developed for making infinitesimal measurements, for it was learned that even as small a variance as 0.001 inch had a decided influence on the finished product. A better understanding than ever before existed of iron in its heated state had to be gained; machinery had to be designed; furnaces, rolls, and everything which had to do with the making of sheet metal had to be changed. Throughout all the industry, Armco engineers collected data, bit by bit. Finally they were certain that all the kinks had been ironed out; and now, instead of strong-armed men passing daily a few tons of sheet bars back and forth by hand between rolls, Armco's continuous mills each have a capacity of 1,400 tons every 24 hours.

The manufacture of special-analysis iron and steel sheets has grown to be an extremely complex business. The industry today is a common meeting ground of engineering and metallurgical science. Several thousand people visit our plants each year, and usually they make one stock comment: "I had no idea the steel business was so complex: all sheet iron used to look alike to me; but now I see that it must be 'tailor made'." And that's a fact, for the industry turns out in the neighborhood of 150 grades, all differing in chemical purity and metallurgical structure.

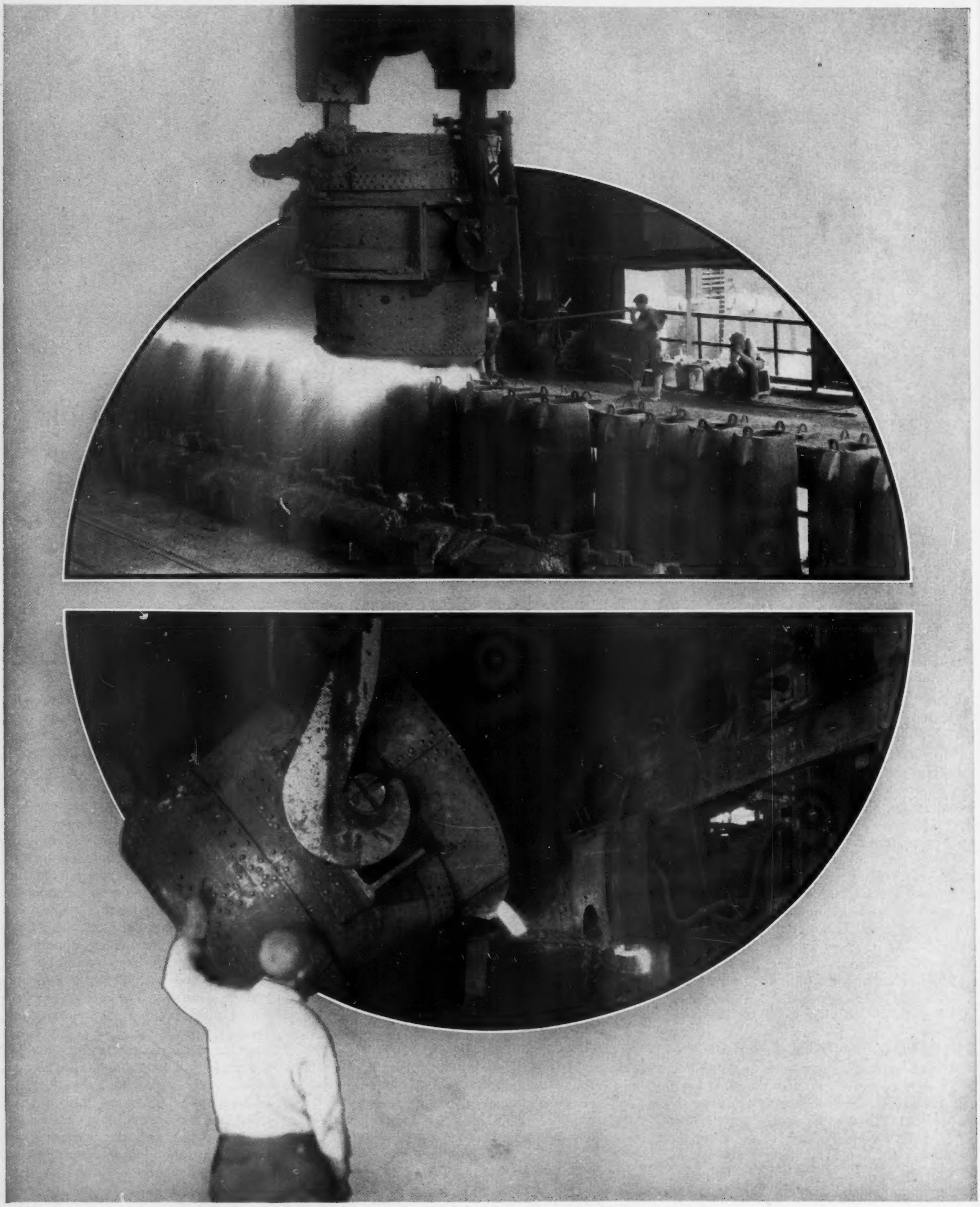
The manufacture of pure iron is indeed a stirring sight. The blast furnace roars away at its task of smelting iron ore night and day, week in and week out. Every four hours it discharges a fiery stream of molten pig iron. The metal is extremely high in carbon content and other foreign elements, and must be purified further in open-hearth furnaces.

The plant of the American Rolling Mill Company at Middletown, Ohio, is located some twelve miles away from its blast furnace. This might sound like an insurmountable difficulty; but engineering genius has provided a way. The metal runs into a ladle that looks like a submarine on wheels. It is a big brick-lined caldron mounted on railroad trucks and constructed on the principle of the thermos bottle. The molten pig iron may be held in this ladle for 24 hours without danger of solidifying.

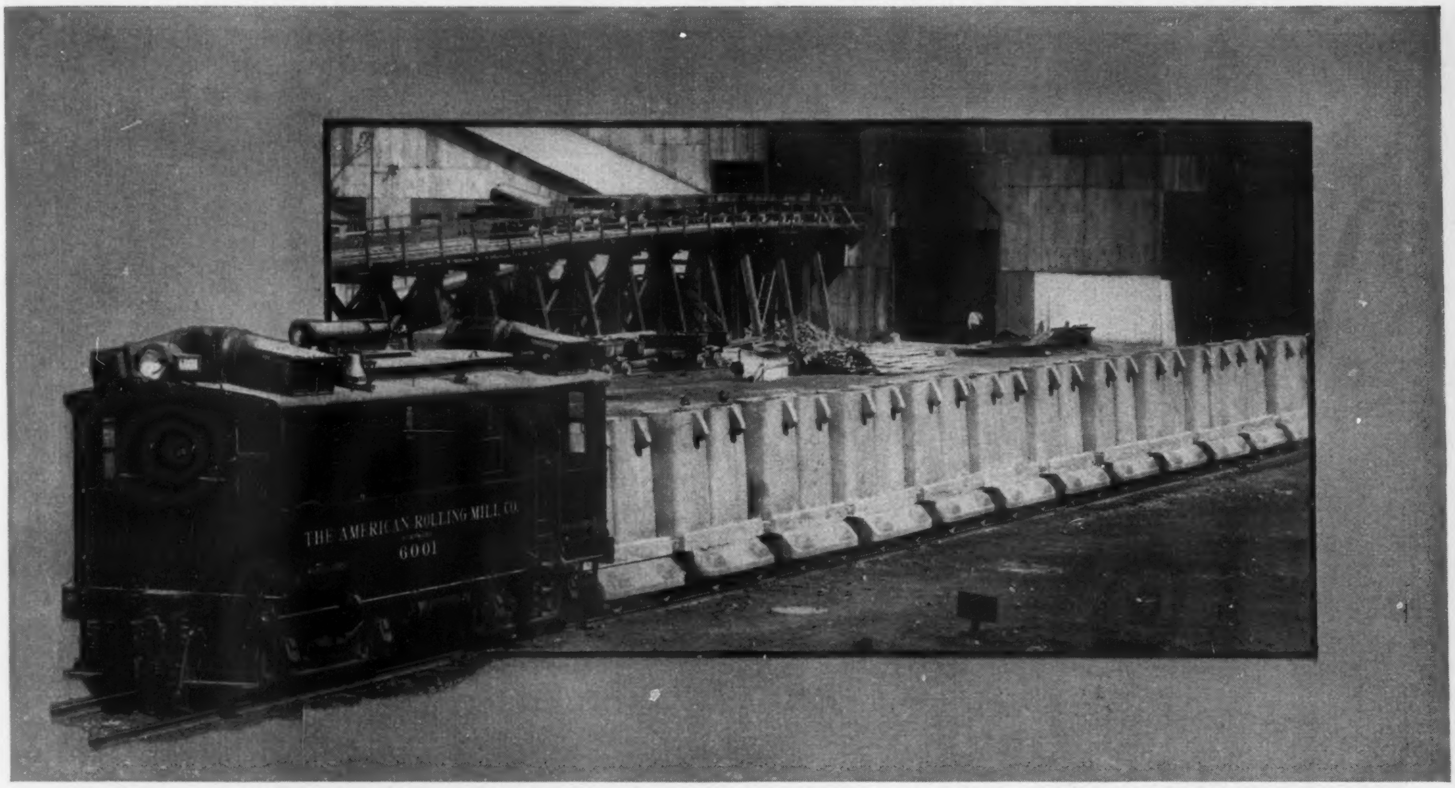
The open-hearth furnace is a great covered hearth about 75 feet long and shaped like an oval saucer. Before receiving the molten pig iron, a quantity of limestone and melting stock is put into the open-hearth. Then huge cranes lift the ladle, and the white-hot pig iron is poured into the furnace. Incandescent flames play over the surface of the materials, which seethe for hours—the most detrimental, rust-promoting impurities in the metal being burned out the while.

Periodically the furnace operator takes a

*The American Rolling Mill Company.



Charging an open-hearth furnace with molten pig iron. Top—After purifying in the open-hearth furnace the metal is teemed into ingot molds.

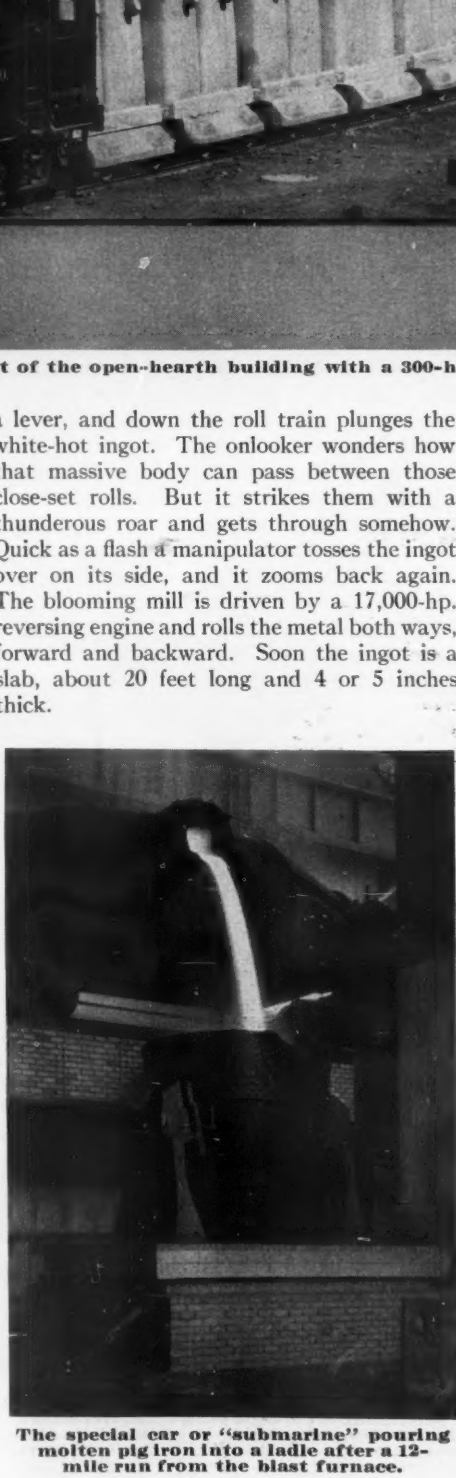


Hauling a train of laden ingot buggies out of the open-hearth building with a 300-hp. Ingersoll-Rand oil-electric locomotive.

test sample of the fluid metal. This is placed in small containers and shot through pneumatic tubes to the laboratory for analysis. Finally, after the chemist has telephoned back that the analysis is right, according to the rigid standard set, there is much hustle and bustle in the neighborhood of the open-hearth furnace. At a signal from the melter, the clay plug that dams the molten bath is knocked out, and with a thundering hiss and a marvelous display of fireworks the iron rushes into the ladle. A monster 250-ton crane approaches and, fastening its talons on to the ladle with its fiery contents, picks it up and conveys it to the pouring platform where row upon row of ingot molds are waiting to be filled. Over these molds the crane hovers; and at the proper moment the ladle pourer presses a release lever and the molten iron teems into them.

With the ladle emptied, an oil-electric locomotive hauls the train of laden ingot buggies out of the open-hearth building. In the open, the ingots are permitted to cool and to solidify. Before long another crane grasps each mold and lifts it from the gleaming ingot while still another crane bears down on the ingots and carries them successively to the nearby soaking pit. There the temperature of each ingot is equalized. As soon as this is accomplished, the overhead crane plunges its two giant fingers down into the blazing pit and draws out the 11,000-pound mass of hot metal. Irridescent with pent-up heat, the ingot is placed on a small car and transported to the roll train.

The ingot is now about to receive its first rolling. Above the great blooming mill is perched the control platform, called the "pulpit", which houses the operators. When all is in readiness, one of the operators touches a lever, and down the roll train plunges the white-hot ingot. The onlooker wonders how that massive body can pass between those close-set rolls. But it strikes them with a thunderous roar and gets through somehow. Quick as a flash a manipulator tosses the ingot over on its side, and it zooms back again. The blooming mill is driven by a 17,000-hp. reversing engine and rolls the metal both ways, forward and backward. Soon the ingot is a slab, about 20 feet long and 4 or 5 inches thick.



The special car or "submarine" pouring molten pig iron into a ladle after a 12-mile run from the blast furnace.

Now comes the first step in that remarkable new process for the continuous rolling of sheets. But to go back to the great 11,000-pound slab of metal. Down a conveyor it shoots—pausing for a few moments in an under-fired slab furnace using producer gas. Then out it darts, only to be suddenly halted beneath giant shears. After removing the ends—which are discarded because they contain harmful impurities, the shears cut the ingot into sections of approximately 1 ton each. In the meanwhile the temperature of the metal has been reduced, making reheating necessary. This is done in an over-fired type of natural-gas furnace. Through this furnace the slab moves on water-cooled rolls embedded in coke breeze. With a loud hiss, the white-hot slab next strikes the water jet curtaining the first set of rolls. It is now in the grip of the continuous mill.

Almost as fast as the eye can follow, the metal shoots through one set of rolls after another, always becoming thinner and longer. Not only is the surface of the metal rolled but the sides also are pressed by edging rolls. There are several stands of rolls in this continuous process, and many of them are four high. In these four-high mills the metal passes between two of the rolls. These rolls, with which the metal comes in contact, are backed up to prevent their springing by two other rolls, thus producing a product of uniform gage. The roll stands are driven by separate motors of from 800 to 3,000 hp. As the long ribbon of metal emerges from the last four-high roll stand it is traveling so rapidly that it would extend a fleet schoolboy runner doing 100 yards in twelve seconds to keep up with it.

Surface scale is one of the enemies of the specialty sheet manufacturer. Loose scale

1—In a manually operated mill where men armed with tongs pass the glowing metal back and forth between the rolls. 2—Section of an Armco continuous mill capable of producing 1,400 tons of sheet metal daily. 3—A strip of metal 150 feet long being discharged from the last roll stand for winding into coils. 4—Coils of sheet metal on their way to the warehouse. 5—Acres of finished sheets ready for shipment to all parts of the world.

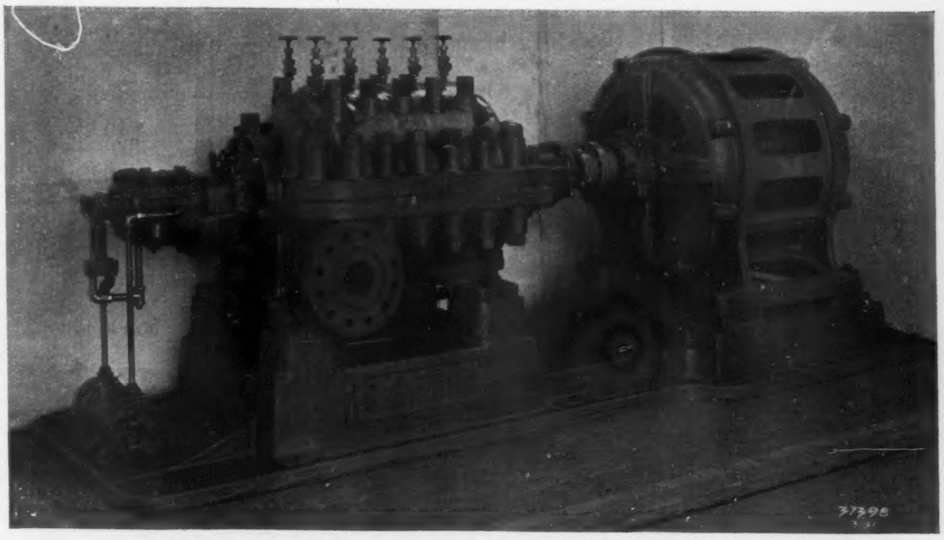
is often rolled in a sheet, causing a pitted surface. In order to avoid this, the American Rolling Mill Company has installed Cameron high-pressure centrifugal spray pumps in its four-high mill. Clean water, shot on to the surface of the metal strip under 800 pounds pressure and at the rate of 1,000 gallons per minute, removes the scale and causes it to fall in a pile under the roll train. The equipment is driven by 750-hp. motors, operating at 1,770 revolutions per minute.

The strip of metal is now some 150 feet long and is next rapidly coiled around a spindle and carried off to the warehouse for storage. From there the coils are withdrawn as they are needed, decoiled, flattened, and cut to any desired length. If sheets thinner than 16 gage be required the metal is taken to the finishing mill for further rolling. But before this rolling takes place the plate is usually passed through a pickling bath of dilute acid which frees it of any surface impurity. Then more rolling, more elongation, and we have what is known in steel-mill parlance as the "green sheet".

The sheets are now stacked in piles, called lifts. Each lift has its own stock card attached; and on it is recorded the open-hearth heat number, when each operation was performed, and other essential information. This ticket stays with the lift while the iron undergoes the remaining stages of manufacture, and is then filed. If necessary, say two years later, one can refer to this card and get the entire history of the lift from the open-hearth furnace onward.

All the sheets in a lift are picked up by a crane and moved to a conveyor. Looking ahead toward the discharge end of the conveyor, one sees a small "swimming pool" into which the sheets are diving. It does seem strange that such common elements as water and air should play an important part in the making of sheet iron; but it will be remembered that the village blacksmith always had a tub of murky water handy. This so-called swimming pool is another pickling bath of dilute acid—the number of picklings which the sheet iron receives being a vital matter. The sheets emerge from the bath free of surface dirt and oxide scale. From this point on they are subjected to several different processes or combination of processes, depending upon the particular grade of metal desired. The fabricator, for example, may want a certain kind of sheet for a certain part, and the iron manufacturer knows what is required to make a sheet that will fill those specifications.

After pickling comes annealing, cold rolling, or roller or stretcher leveling, and as many different combinations of these as will produce the type of sheet needed. Annealing consists of exposing the metal to a slow penetrating heat either by passing it continuously through a gas-fired furnace or by covering piles of sheets with huge cast-iron annealing boxes. If the latter method be chosen, the box with its load is moved into a large furnace and permitted to remain there for many hours. This tempers the iron so that it is ductile and workable in the dies. Cold rolling involves passing cold sheets between revolving rolls. This treatment improves the surface and imparts to the sheet the proper temper or stiffness. Roller leveling is used where sheets must be of ordinary flatness, while stretcher leveling is resorted to whenever unusual flatness is desired.


The type of high-pressure centrifugal pump installed in the four-high mill to wash scale from the sheets in process of rolling.

But even after all these operations have been completed, the sheet is not ready to ship. It must be sheared down to the size the customer has ordered, and then inspected. The latter work calls for exceptional skill. Under the artificial light of mercury-vapor lamps, inspectors scan each piece of metal for surface defects; and frequent tests showing various physical properties of the metal are made in a nearby laboratory. Any sheet which fails to meet the rigid inspection standards is cast aside.

In case the customer wants a galvanized sheet, still further handling is necessary. Somewhere back in the production line the metal is detoured to the galvanizing department. Again it is pickled in dilute acid, for in galvanizing it is absolutely essential to start with a clean surface. Each lift is cleansed separately, and then stored in great vats of water until the operator of the galvanizing machine is ready for it. He passes sheet by sheet through the galvanizing pot, which contains a supply of molten spelter. As the sheets emerge, the sudden cooling causes those beautiful spanges which are a distinguishing mark of galvanizing.

The perfection of the continuous-rolling process has changed the entire outlook of the industry. Armco's three complete units at Ashland, Ky., Butler, Pa., and Middletown, Ohio, have a capacity of more than 1,000,000 tons of finished sheets per year. The advantages of the process have not been withheld from other manufacturers. The United States Steel Corporation, the Weirton Steel Company, the Otis Steel Company, the Great Lakes Steel Company, the Republic Iron & Steel Company, the Youngstown Sheet & Tube Company, the Wheeling Steel Corporation, and the Inland Steel Company all have been granted licenses to use it.

New York City is served by 9,400,000 miles of telephone wire.

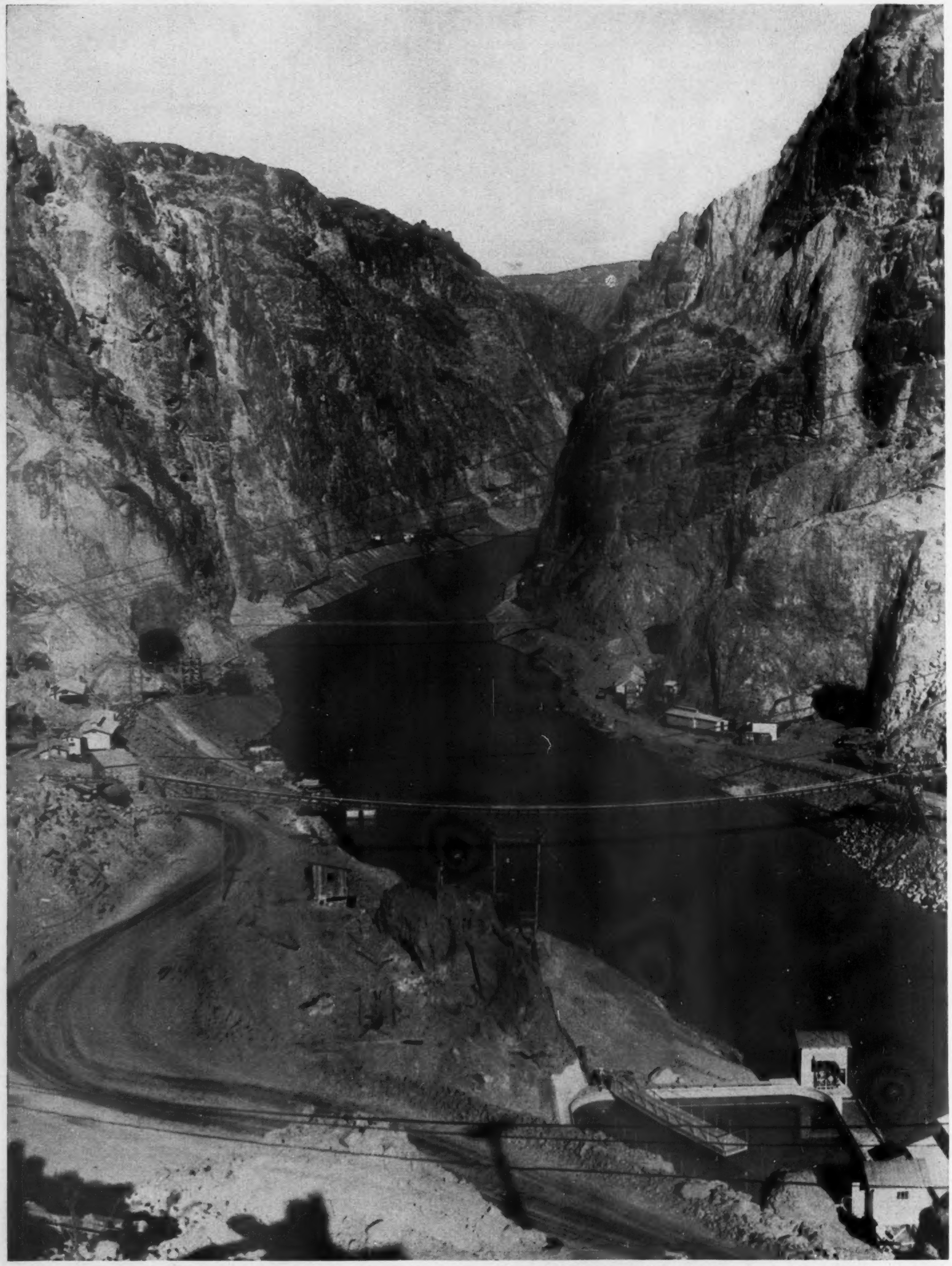
TALL STEEL BUILDINGS SAFEGUARD LOWER ONES FROM LIGHTNING

HUNDREDS of structures on the Island of Manhattan no longer have anything to fear from lightning, now that the Empire State Building reaches nearly a quarter of a mile into the sky. And, being well grounded by its mass of steelwork, the Empire State Building, itself, has nothing to fear from that quarter.

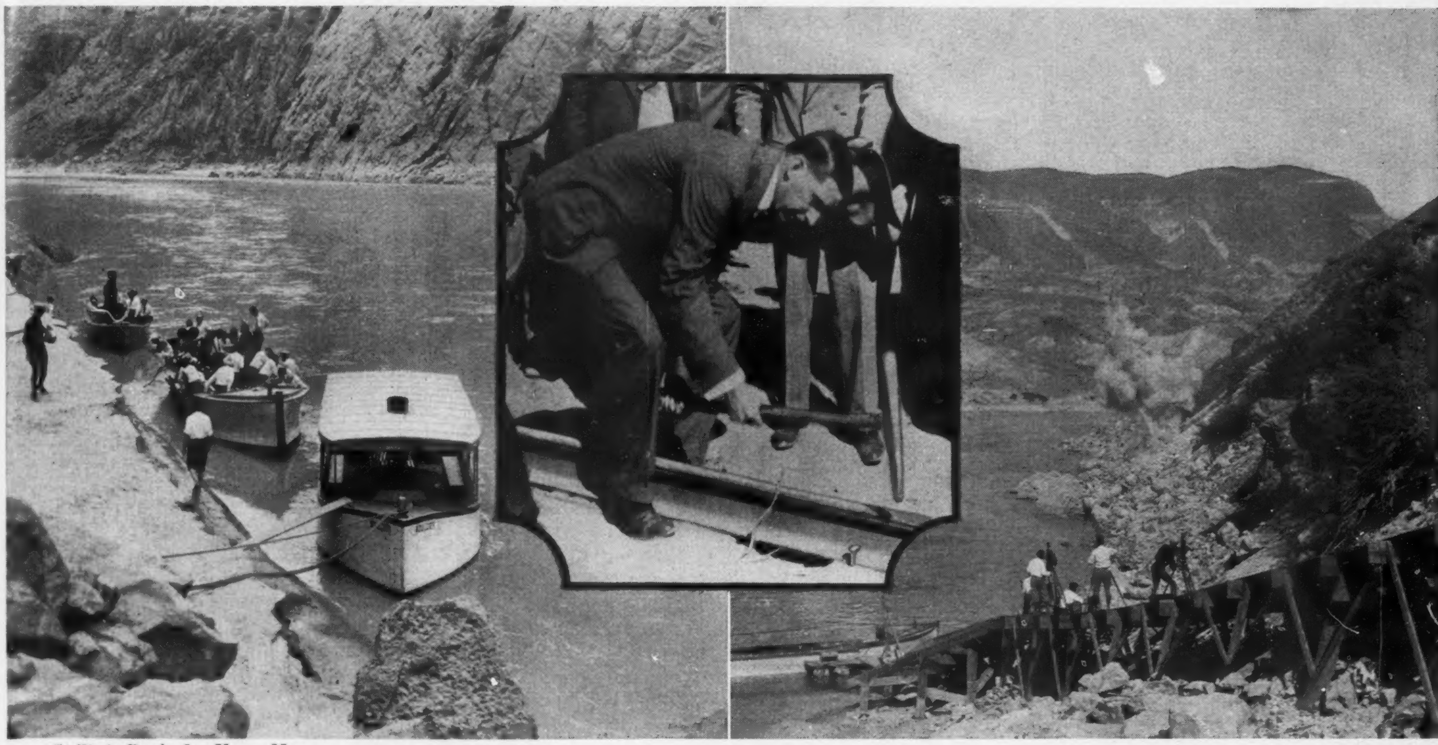
Experiments with 5,000,000-volt bolts of artificial lightning in the high-voltage laboratory of the General Electric Company at Pittsfield, Mass., have proved that the world's tallest structure offers protection against lightning to all buildings, with the possible exception of one or two nearby skyscrapers, within a considerable radius of it. New York's sky line in miniature was used for the tests. Bolt after bolt of the 5,000,000-volt man-made lightning was hurled "earthward", and each time the pinnacle of the Empire State Building was struck. It suffered no damage, however, as the model, just like its original, was well grounded.

The zone of protection is cone-shaped, and when the clouds are a mile high the area immune to attack is embraced within a line drawn from the top of the skyscraper and having a radius about 2.5 times the height of the building. But should the storm cloud hang exceptionally low, a quarter of a mile overhead, the zone of protection might be reduced to a radius equaling the height of the structure. As compared with a low steel structure, the Empire State Building is actually less efficient as a means of shelter because of its height, which brings it nearer to the clouds. The safety zone around the lower building may be four times its height.

What the scientists have discovered in the laboratory has been put to practical use in safeguarding oil storage tanks in southern California and elsewhere against fire induced by lightning. Tall rods have been erected at definite points near the tanks so as to provide overlapping areas of protection. These rods, like the Empire State Building, attract the lightning, and thus shelter the adjacent lower structures.



Looking upstream in Black Canyon toward the site of the Hoover Dam. The lower portals of three of the four diversion tunnels are shown. In the lower right-hand corner is the settling basin where river water is clarified before being pumped six miles to Boulder City. The dam will be built at about the point where the river disappears behind the cliff at the right. From a photograph made about December 1, 1931.



(C) W. A. Davis, Las Vegas, Nev.
Left—Bureau of Reclamation officials on an inspection tour in Black Canyon. Right—The first blast which was fired just above Black Canyon on September 16, 1930. Insert—Secretary of the Interior Wilbur driving a spike of Nevada silver to mark the beginning of construction of the railroad to Boulder City.

Construction of the Hoover Dam

*Some General Facts Regarding the Undertaking and the Men Who are Directing It**

By C. H. VIVIAN

BIDS for the construction of the Hoover Dam, power plant, and appurtenant works were opened March 4, 1931, at the Denver office of the Bureau of Reclamation. Only three bids were submitted, although contractors from all sections of the country were present and many of them had expected to bid until the time set for the opening drew near. The lowest bid, submitted by Six Companies Incorporated, of San Francisco, and subsequently accepted, was $48,890,-995.50. The second bid of $53,893,878.70 was submitted by the Arundel Corporation, of Baltimore, associated with Lynn H. Atkinson of Los Angeles. Woods Brothers Construction Company, of Lincoln, Neb., and A. Guthrie & Company, of Portland, Ore., were the third bidders with $58,653,107.50.

The voluminous plans and specifications prepared by the Government engineers, and appraised as models of their kind, divided the complete work into 119 separate items for bidding. On most of these items the three bids were fairly uniform. The only outstanding difference between the two lowest bids was on the item of placing 3,400,000 cubic yards of concrete in the dam, the respective figures being $2.70 and $4.15 per cubic yard. This variation accounted for $4,930,000 of the $5,002,883.20 difference between those bids. Both concerns bid $8.50 per cubic yard for the tunnel excavation. The three largest items in the successful bid were $13,285,000 for the 1,563,000 cubic yards of tunnel excavating; $9,180,000 for placing the concrete in the dam; and $3,432,000 for lining the diversion tunnels with 312,000 cubic yards of concrete. No other single item was as much as $1,000,000. From the foregoing facts it can be seen that the construction of the dam and its associated works resolves itself into the performance of a few major tasks and a multitude of smaller but closely related ones. The successful bid was only $24,000 more than the estimated cost as computed by the Government engineers. This was considered remarkably close figuring in view of the great size of the undertaking.

U. S. Bureau of Reclamation
Dr. Elwood Mead, Commissioner, Bureau of Reclamation.

Upon the occasion of signing the authorization of the contract on March 11, Secretary Ray Lyman Wilbur of the Department of the Interior commented that it was the largest contract ever let by the Federal Government. He predicted that the consummation of the project would transform the desert region below the dam site into one capable of supporting 5,000,000 persons. "It is a satisfaction to see this great contract get under way", he said. "The Colorado River, instead of being a menace, will now be a great benefit".

Just how this project compares in size with previous ones of the same general character, may be judged by the fact that the Bureau of Reclamation, during the 29 years of its existence prior to 1931, let contracts calling for an aggregate use of 4,400,000 cubic yards of concrete, whereas 4,500,000 cubic yards will be required for this one job.

The terms of the contract, which departed

**Fourth of a series of articles on the Colorado River and the building of Hoover Dam.*

Some leading figures in the Hoover Dam project. From left to right—Ray Lyman Wilbur, Secretary of the Interior; Walker R. Young, resident construction engineer for the Bureau of Reclamation; F. T. Crowe, general superintendent for Six Companies Incorporated; Raymond F. Walter, chief engineer, Bureau of Reclamation.

somewhat from established practices, were considered very fair by bidders. They provide that the Government shall purchase practically all materials required, such as cement, steel, etc. This relieves the contractors from possible losses arising from fluctuations in the costs of materials. Accordingly, bidders were able to figure more closely the actual costs of doing the work. Another provision favorable to the contractors is that the Government will assume all damage which may result from floods experienced after the cofferdams and diversion tunnels are completed and accepted. This means that for more than two-thirds of the period of construction, the contractors will be relieved of loss from high water.

The entire work to be carried on under the Hoover Dam contract consists of five major divisions:

1. River diversion works, consisting of upstream and downstream cofferdams and four tunnels through rock, each 56 feet in diameter before lining with concrete and approximately 4,000 feet long.

2. A concrete arch gravity type dam 1,180 feet long on the crest and 727 feet high, with a radius of curvature of 500 feet.

3. Two spillways, one on each side of the river, each consisting of a 50x50-foot stoney gate, a concrete ogee overflow crest 700 feet long, and a concrete-lined open channel.

4. Twin outlet works of similar design and capacity, each consisting of two separate systems regulated by cylinder gates in the bottom of intake towers.

5. A U-shaped power house of concrete and structural steel immediately below the dam.

The Government will furnish all materials and equipment that become a permanent part of the completed structure, delivering it to the contractors at Boulder City, the construction town. The hydraulic and electrical machinery, equipment, and wiring for the power house will be installed by the Government, and the contractors will place concrete around such machinery as it is installed. The Government will also furnish and Six Companies Incorporated will install an inclined freight-car elevator alongside the canyon wall immediately below the power-house site on the Nevada side of the river. This will connect at its upper end with a highway from Boulder City, and will be available for transporting machinery and supplies for the power house to the canyon bottom, a vertical distance of approximately 600 feet. Sand, gravel, and stone for concrete will be taken by the contractors from a Government owned property known as the Arizona gravel pits located eight miles up the river from the dam site.

From an engineering standpoint, one of the most interesting clauses in the contract is that providing for induced cooling of the concrete in the dam as it is poured. The chemical reaction which takes place during the setting of concrete is accompanied by the generation of considerable heat. If large blocks are poured at a time, subsequent cooling may result in the development of contraction cracks. To promote cooling, it is customary to build large concrete dams in a series of columns of rectangular section and to leave spaces between these columns to provide for the greatest possible exposure of the faces to the air. Columns are built up in stages, the amount of concrete poured at a time being limited sufficiently to permit ample cooling before more material is placed on top of it. The spaces between the original columns are later filled with other columns, which are likewise built up progressively. Subsequent grouting helps to consolidate them into a solid or monolithic structure.

Because of the great mass of

Installing a 7,000-cubic-foot-per-minute compressor plant at lower end of the work on the Nevada side of the river.

Three officials of Six Companies Incorporated who are closely identified with the momentous work in hand. From left to right—Henry J. Kaiser, chairman of the executive committee; Charles A Shea, director in charge of construction activities; and Director H. J. Lawler.

concrete—3,400,000 cubic yards—that will go into the Hoover Dam, however, the time required for its cooling by natural means would be unduly long. To expedite matters, it was decided to follow the columnar method of construction and to hasten cooling by circulating cold water through the concrete by means of built-in pipes. For this purpose, there will be 800,000 linear feet of 2-inch pipe or boiler tubing embedded in the concrete. This piping will remain a permanent part of the structure, and will be filled with grout under pressure.

Cold water for circulating through the concrete will be supplied by a refrigerating plant maintained by the contractors. With a thought for this latter phase of the work, Six Companies Incorporated bought air compressors for the initial or drilling phases of the operations that can readily be transformed into ammonia compressors on the ground. The compressors are Ingersoll-Rand 2-stage units driven by synchronous motors. Some are of the large Class PRE design: others are the intermediate size designated as Type XRE.

Most of the work during the first three years will consist of excavating and tunneling and making ready for subsequent operations. Placing of concrete in the dam proper is not scheduled to begin until December 1, 1934. The time allowance for completion of the contract is 2,565 days, or approximately seven years. The contractors are subject to a penalty of $3,000 for every day of overtime required to complete each of the five divisions of the work.

Six Companies Incorporated is a combination of six prominent contracting concerns operating in the West. It was incorporated in February, 1931, for the express purpose of pooling resources, experience, and personnel in so far as the Hoover Dam is concerned. For all other purposes, the several member firms have retained their individual identities and are carrying on their separate activities as before.

The firms making up Six Companies Incorporated, with the percentages of their participation in the profits or losses that may accrue from this contract, are: W. A. Bechtel, San Francisco, and Henry J. Kaiser, Oakland, Calif., 30 per cent; Utah Construction Company, Ogden, Utah, 20 per cent; MacDonald & Kahn Company, Los Angeles, 20 per cent; Morrison-Knudsen Company, Boise, Idaho, 10 per cent; J. F. Shea Company, Portland, Ore., 10 per cent; and Pacific Bridge Company, Portland, Ore., 10 per cent. These companies had, collectively, completed $409,000,000 in contracts up to March, 1931, and had underway other work totaling more than $30,000,000. All told, they had carried out 3,024 individual contracts, of which 178 were for Government work, and had 69 additional contracts in hand at the time they were awarded the Hoover Dam undertaking.

Of these member companies, the Utah Construction Company is perhaps the best known, as it has fulfilled contracts in virtually every state in the western third of the country. Since its formation, in 1900, it has done approximately $200,000,000 worth of contract work—chiefly railroad construction, but including also considerable irrigation and reclamation work. The Pacific Bridge Company was organized in 1869 and has specialized in bridge building, particularly in underwater foundation work. W. A. Bechtel Company has been operating for seventeen years, during which period it has completed approximately $30,000,000 worth of railroad, dam, and general construction contracts. Kaiser Paving Company, Ltd., dates its corporate existence back to 1913, and has specialized in paving contracts. MacDonald & Kahn Company, made

River camp of Six Companies Incorporated, at Cape Horn, above Black Canyon, where some 400 workmen make their homes.

Left—A section of "Ragtown", a riverside mushroom settlement above Black Canyon. Right—Black Canyon, viewed from above. Bottom—A pack train of one of the Government's early surveying expeditions along the Colorado.

up of Alan MacDonald and Felix Kahn, has a record of $75,000,000 in contracts fulfilled, consisting chiefly of building construction on the Pacific Coast. The firm was formed in 1920. The Morrison-Knudsen Company, composed of H. W. Morrison and M. H. Knudsen, has been in business since 1912 and has completed $30,000,000 worth of contracts covering the building of roads, railroads, dams, and other construction work. J. F. Shea Company has accounted for some $40,000,000 in contracts since its organization in 1914. It has done a general contracting business, with special attention to tunnel work.

It can be seen from the foregoing brief resumé of their past activities that the component members of Six Companies Incorporated are admirably equipped to supervise and perform the many and diverse tasks that enter into the building of the Hoover Dam. Their combined experience covers every phase of the work now in hand. Some of the things to be done in Black Canyon are on a larger scale than ever before attempted, but among the personnel of the contractors are men who have had ample theoretical and practical acquaintance with the problems involved.

The officers of Six Companies Incorporated are: W. A. Bechtel of Bechtel & Kaiser, president; E. O. Wattis of the Utah Construction Company, first vice-president; H. W. Morrison of the Morrison-Knudsen Company, second vice-president; Felix Kahn of MacDonald & Kahn Company, treasurer; Charles A. Shea of J. F. Shea Company, secretary; K. K. Bechtel of Bechtel & Kaiser, assistant secretary and treasurer, W. H. Wattis, elected president of the company at the time of its organization, died in September, 1931. He was for many years an officer of the Utah Construction Company, and was one of the leading construction men of the West. Directors of the company are: W. A. Bechtel, S. D. Bechtel, Philip Hart, Henry J. Kaiser, Felix Kahn, Alan MacDonald, H. W. Morrison, Charles A. Shea, E. O. Wattis, H. J. Lawler, and Guy LeR. Stevick.

While all the directors of Six Companies Incorporated visit the operations at regular intervals, the active management is in the hands of an executive committee composed of four members—Henry J. Kaiser, chairman; Charles A. Shea, director of construction; Felix Kahn, in charge of all activities of the subsidiary Boulder City Company which is charged with the feeding, housing, and transporting of the men; and S. D. Bechtel, in charge of purchasing, auditing, and warehouse activities. Mr. Shea spends most of his time on the job, and is as active as Francis T. Crowe, the general superintendent of Six Companies Incorporated, in supervising the manifold construction details involved. He acts as contact man between the board of directors and the operations personnel. In addition to the Boulder City Company, another subsidiary, the Hoover Dam Transportation Company, was formed.

The man upon whose shoulders rests the chief responsibility for carrying through this record-breaking contract is the general superintendent. Mr. Crowe is thoroughly schooled in the work he is directing, both from the standpoint of the contractors and of the Government bureau for which the work is being done. He is 49 years old, and was graduated from the University of Maine. He entered the service of the Bureau of Reclamation in 1904 as engineering aid, and was advanced until he was general superintendent of construction attached to the Denver office when he resigned in 1925. While with the Bureau he was in charge of construction of the Jackson Lake Dam in Wyoming and of the Tieton Dam on the Yakima Project in Washington, the latter an earth-and-rock fill structure 222 feet high. He served for a time as assistant to the construction engineer on the 349-foot Arrowrock Dam in Idaho. He also was project manager of the Flathead (Indian) Project in Montana. In 1925 Mr. Crowe went with the Utah Construction Company and the Morrison-Knudsen Company, jointly, as superintendent of construction. In that capacity he had charge of the building of the Gibson and Deadwood dams, both Bureau of Reclamation enterprises.

Mr. Crowe will "live on the job" both literally and figuratively until the Hoover Dam is completed. He established his residence at Boulder City soon after the bids were opened, and has since been there almost continually. It is not unusual to find him down in the canyon at 12 o'clock at night and again at 5 o'clock the following morning. He has surrounded himself with a group of efficient assistants for directing the tasks in hand. Most of his immediate staff were taken from the various member firms of Six Companies Incorporated. Virtually all of them have had years of experience in construction work similar to that now facing them. To Mr. Crowe and his assistants the building of the Hoover Dam is just another job—a job that

differs from previous accomplishments only in point of size and time requirement.

Something has been said in previous articles of this series about the extensive investigations, by Government engineers, which led to the selection of the Black Canyon site. Any account of the building of the Hoover Dam would be unfair and incomplete if it did not pay tribute, at the outset, to the Bureau of Reclamation for its part in paving the way for the contractors. Once the dam site was chosen, an almost incomprehensible amount of detail work had to be done in the field in order that adequate plans and specifications might be prepared. As these data were obtained, their translation into printed forms necessitated an enormous amount of office engineering work.

Unfortunately, there is not available a written record of the activities of the field force. It goes without saying that many hardships were endured. Whereas the men who build the dam will live in a modern, sanitary, city, the engineers who pioneered this great undertaking had only a cluster of tents that they could call home. Deprived of all but the most primitive necessities, they traversed a country without roads and almost without shade, risked their lives on precipitous rock walls, and carried on in blistering summer heat. Dr. Elwood Mead, Commissioner of Reclamation, gives a hint of what confronted them in the following words:

"The survey of the dam site and reservoir was of unprecedented magnitude and difficulty. It involved coping with a river which, in the highest floods, rushed through the canyon with the speed of a railway train; of taking topography in more than 100 miles of canyon where precipitous cliffs 1,000 feet high and of indescribable ruggedness had to be scaled. Three lives were lost in this hazardous undertaking. Every phase of the work involved great danger, but the dimensions of the possible dam and reservoir had to be known. Then there had to be a topographic map.

"Anyone who views the canyon either from the top of the rim or from the river at the bottom has a sense of the peril and hardship involved in fixing locations and making measurements on its cliffs. To have done this work by the old methods would have delayed beginning construction six months to a year. Resort was had to aerial surveys. This involved great hardship because of the intense summer heat and in making observations at great differences in elevation".

While the Bureau has discharged with credit its great task of preparing the engineering preliminaries for this mammoth undertaking, it is still faced with the responsibility of supervising and checking every phase of the construction activities to see that the plans and specifications are faithfully followed. Space permits mention of only a few names of individuals who have been and will continue to be prominent in the Government's part in the building of the Hoover Dam.

As the Bureau of Reclamation is a division of the Department of the Interior, Secretary Wilbur is the nominal head of its activities. Having served as president of Stanford University and lived in the West for many years, he carried with him to his present office a thorough understanding of the Colorado River problem and a realization of the benefits that would result from its solution. It was through him and his assistants that the agreements and contracts were carried through which made possible the start of actual construction operations.

Doctor Mead, directing head of the Bureau of Reclamation, is declared by many to be the world's leading authority on land reclamation. A long list of completed projects in the western part of the United States bears testimony to his efforts; and he has served as consultant and director on similar work in Australia and Palestine. Like Secretary Wilbur, he is a western man, having started his engineering career as state engineer of Wyoming.

As chief engineer of the Bureau and head of its Denver office, Raymond F. Walter had active charge of the engineering staff which planned and designed the Hoover Dam and its appurtenant works. He is a specialist on problems connected with irrigation and with power development. John L. Savage served as chief designing engineer for the dam.

Walker R. Young is resident construction engineer. He designed the Arrowrock Dam, until recently the highest in the world. He was in charge of the Kittitas division of the Yakima Project, which involved a unique and very difficult task of canal construction, and directed the field work in connection with the investigations of dam sites on the Colorado River. The Bureau of Reclamation has maintained an office at Las Vegas, Nev., 30 miles from the dam site, since construction began, and will this month move into the Government administration building in Boulder City. John C. Page is office engineer there.

BALLOONS SERVE AS GAS HOLDERS IN AN EMERGENCY

LARGE inflated balloons anchored in an open field are not always an indication of an ascension. At least, two balloons were seen in the outskirts of Ravenna, Ohio, and were not known to take off once even though they were charged with gas. Investigation revealed that those two balloons were saving the day in an emergency—they were serving in the capacity of gas holders, proving once again that there is usually a way out of a difficulty.

The situation that confronted the East Ohio Gas Company at first appeared to be more of a problem than it turned out to be, thanks to a bright idea. The company had found it necessary to replace about 2,600 feet of 8-inch piping at three different points in its Kent-Ravenna branch line, and the question was how to avoid laying a temporary 6-mile by-pass line to maintain Ravenna's gas supply during the tie-in. Here is where the balloons came in.

The company rented two Goodyear balloons, each with a capacity of 35,000 cubic feet. These were stationed in a meadow above pits that had been dug for their inflation—the gas being drawn direct from the nearby main through a "Y" connection. Between the pits was run a 4-inch manifold, and a portable air compressor was interposed between the manifold and the Ravenna high-pressure system. When all the arrangements had been completed, the Kent-Ravenna branch was closed down, but not until test had proved the unique supply plant equal to its task. In the meantime the pressure in the Ravenna distributing lines had been increased from 32 to 36 pounds.

It took just 55 minutes to break the main at the three points where it was under repair; to connect the old piping with the new that had been laid parallel to it; to remove the air; and to make the final tie-in. During that time the emergency gas holders and associate equipment functioned without a hitch, keeping the pressure constant at 36 pounds.

Gondolas with an inside length of 65.5 feet have made their appearance on an important trunk-line railway in the United States. These carriers are in answer to a demand for individual cars capable of accommodating the long structural parts, pipes, sheets, and rails that are now made and shipped. The gondolas as commonly used are from 35 to 50 feet long.

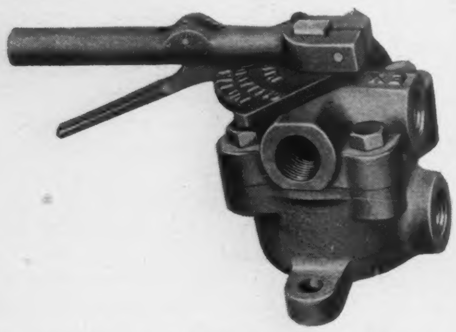
Courtesy, Western Gas

The inflated balloons with the portable compressor midway ready to keep Ravenna supplied with gas during a hook-up in the main distributing system.

AIR VALVE FOR JOLT-SQUEEZE MOLDING MACHINES

A SPECIAL air valve for jolt-squeeze or squeeze-draw molding machines has been developed by the Galland-Henning Manufacturing Company of Milwaukee, Wis. The "Nopak", as it is known, is a 4-way valve that, as the name implies, needs no packing. It is said to do the work of two of the 3-way valves now commonly used for molding machines of the aforementioned type.

The new valve is equipped with a safety handle which, when thrown to one side, operates the jolt and, when swung to the opposite side, brings the squeeze into action. The handle does not need to be held in either position, thus leaving the foundryman's hands free for work. Neither does the "heel" of his hand become badly calloused because the valve handle is not operated against the line air pressure and therefore requires no forcing. Full exhaust of both cylinders is assured in either the locked-neutral or center position.



The new "Nopak" 4-way valve for use in foundries.

According to the manufacturer, the "Nopak" jolt-squeeze valve tends to speed up production, cuts the cost of repairs and replacements to a minimum, and prevents costly air leakage. It comes in three standard sizes: for 3/8-, 1/2-, and 3/4-inch pipe openings. Other sizes, however, can be obtained upon request.

ACKNOWLEDGMENT

IN OUR issue of last October was published an article entitled, *Isle of Man Making Ready for More Visitors*. We regret that the concluding paragraph of the original text was omitted. On behalf of the writer we now wish to acknowledge that the information and the photographs reproduced were graciously furnished by Messrs. H. A. Bridge, engineer and surveyor of the Borough of Douglas, J. C. Bregazzi, and W. A. Clague. Mr. J. H. Blaker, chief engineer of the Isle of Man Harbor Commission, is in charge of the work.

A special locomotive making but twenty miles an hour has been built to haul the navy's new giant dirigible *Akron* in and out of her hangar. The engine was purposely designed to travel at slow speed so as to prevent any harmful jerking or straining of the airship while in transit on the ground.

DIESEL REFERENCE GUIDE, by Julius Rosbloom. A profusely illustrated volume of 292 pages, published by the Industrial Institute, Inc., Jersey City, N. J. Price, $10.00.

THIS volume is a compendium of information having to do with Diesel engines in their manifold field of service. This type of prime mover is discussed theoretically as well as practically; and the author touches upon the principles of construction as well as the principles of operation. In addition to the various mechanical aspects of his subject, the author has provided, in Section II of his book, an index of Diesel manufacturers in America and abroad.

MASTER MINDS OF MODERN SCIENCE, by T. C. Bridges and H. Hessell Tiltman. An illustrated volume of 278 pages, published by Lincoln MacVeagh, The Dial Press, New York. Price, $3.00.

THIS book might well be summed up as a record of the outstanding wonders wrought by men of science in the course of a little over a century. It is fitting that we of the present age and generation should be reminded of how the nineteenth century well-nigh completely changed the face of the civilized world. As the authors express it: "Trade, transport, and education were revolutionized; food, clothes, all the necessities of life were made cheaper and more plentiful; the poorer folk were given comforts and conveniences of which even the rich had known nothing a hundred years before. Science shed light upon dark places, and it has linked up the whole world. During the current century the power of science is increasing like a snowball." The book tells us of the scientists who have made this astonishing change an accomplished fact and of their work. It is an absorbing recital from beginning to end.

THE NEMESIS OF AMERICAN BUSINESS, by Stuart Chase. A book of 191 pages, published by the Macmillan Company, New York. Price, $2.00.

THE author, in a pleasing and entertaining manner, has ripped apart the present-day fabric of our national life and, without malice, has pointed out its flaws and made a number of suggestions that seem to offer practical measures for the reweaving of our economic texture in a way that will lessen the likelihood of unemployment and its associate misfortunes. One may not be ready to accept offhand Mr. Chase's remedies; but there is logic enough in even the most debatable of them to justify consideration. His attitude towards his subject is not only critical but constructive, and in this he differs radically from the all-too-numerous faultfinders and pessimists.

Is he chasing rainbows, is his hopefulness different from that of most of us, when, in his summing up, he writes: "Granting for the time being—until coal is gone, and the Ice Cap moves south again—granting that a beautiful life here and now should be the major goal of human effort, of what strands shall it be woven? The above is, if you will, a feeble and over-personal beginning. But I offer it as a preface to the work of the engineers that are to come."

THE FORD MODEL "A" CAR AND "AA" TRUCK, Its Construction, Operation, and Repair, by Victor W. Page. A copiously illustrated volume of 703 pages, published by the Norman W. Henley Publishing Company, New York. Price, $2.50.

ANY motor car will go farther, last longer, and pay larger dividends on the investment according to the degree of understanding possessed by the owner of the mechanical get-up of his car, plus the application of that knowledge in the care and maintenance of the machinery entrusted to his management. The present book was compiled for that very numerous group of Ford car owners; and while originally brought out to deal with Model "T", it has now been revised so as to give corresponding information about the Model "A" car and the "AA" truck.

AIR BRAKE INSPECTOR'S HANDBOOK, by Carl O. Glenn. A copiously illustrated book of 328 pages, published by Simmons-Boardman Publishing Company, New York. Price, $3.50.

THERE is a very considerable number of our citizenry employed in railroading on trunk lines, branch lines, and temporary lines run in connection with large engineering undertakings of one kind or another. These people have to do with air brakes; and the successful execution of their several responsibilities calls for a more or less comprehensive understanding of air brakes and their operation. The present book is so written and illustrated as to promote familiarity with the get-up and the manner of working of different types of air-brake equipment.

METAL STATISTICS, 1931. A book of 552 pages, published by the American Metal Market, New York. Price, $2.00.

FOR twenty-four years *Metal Statistics* has appeared annually, each edition containing a general assortment of statistical information concerning ferrous and non-ferrous metals. In the present volume, however, are various new tables which are believed to be of added usefulness to the trade. Besides, considerable economic data has been inserted covering a fairly wide range of topic matter. We feel sure that this handy volume will be welcomed, as heretofore, by all persons interested in the field covered.

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